mL007748
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Next Assembly	Used On	REVISIONS		Rev	
		Ltr	Description	Date	Approved
First Application					

OCT

For Continuation of Revisions, See Sheet

	Contract No. NAS5-30350	LOCKHEED MARTIN SPACE SYSTEMS COMPANY MISSILES & SPACE OPERATIONS, SUNNYVALE, CALIF. 94088
REE. 9/10/02	Written Date 9/10/02	SATELLITE TO GROUND INTERFACE (NOAA N-N')
	Approved Date 9/10/02	
	Approved Date	Size A | Code Ident No. 06887 | IS23033284
Prod As. Date 9/11/02		Sheet 1 of 82

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This document is now released under Class 1 Configuration Management Control per MMAS document 2308226, Configuration Management Plan for TIROS.

Karen Halterman

GSFC POES Program Manager

LMSSC-MSO TIROS Program Manager

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APPENDICES

TABLES

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FIGURES

1.0 SCOPE

This document is not a spacecraft or Ground Station requirements document. The purpose of this document is to describe the available spacecraft transmitted data streams and the various spacecraft to ground interfaces. Predicated on spacecraft requirements, and the availability and correctness of ground station information, this document describes/predicts the link performance with the two NOAA/NESDIS CDA ground stations (Wallops Island, VA and Fairbanks, AK). Data users and system developers must consult the appropriate Performance Specification listed under Section 2.0 to obtain requirements for design applications.

2.0 APPLICABLE DOCUMENTS

The specifications listed below form a part of this document. In the event of conflict between this document and any listed specification, the applicable specification shall govern.

LMSSC-MSO

IS-20046415	Interface Specification – Microwave Humidity Sounder
PS-20057860	Performance Specification – MHS Interface Unit
PS-2284374	Performance Specification – TIROS Information Processor (TIP)
PS-NNP3288504	Performance Specification – AMSU Information Processor (AIP)
PS-2284391	Performance Specification – Manipulated Information Rate Processor (MIRP)
PS-2284379	Performance Specification – Cross Strap Unit (XSU)
PS-2285211	Performance Specification – Communication Subsystem
PS-2629937	Performance Specification – GSTDN Command Receiver (GRD)
PS-2285212	Performance Specification – Command Subsystem
PS-2280287	Performance Specification – VHF Real-Time Antenna (VRA)
PS-20038448	Performance Specification – S-Band Data Antenna (SBA)
PS-3288057	Performance Specification – UHF Data Collection System
PS-2280284	Performance Specification – VHF Beacon/Command Antenna (BDA)
PS-3265453	Performance Specification – S-Band Data Transmitters (STX)
PS-3288236	Performance Specification – Search & Rescue Antenna (SRA)
PS-2288274	Performance Specification – S-Band Omni Antenna (SOA-1, 2)
PS-2628492	Performance Specification – S-Band Omni Antenna (SOA-3, 4)
PS-3284970	Performance Specification – S-Band Omni Antenna (SOA-5, 6)
PS-2297967	Performance Specification – Search & Rescue L-Band Antenna (SLA)
IS-23033280	Interface Specification – Search & Rescue Processor (SARP-3)
PS-3288236	Performance Specification – Search & Rescue Antenna (SRA)
PS-N2285208	Performance Specification – Data Handling Subsystem (DHS) for NN'
IS-23033279	Interface Specification – Advanced Data Collection System (ADCS)
PS-8575315	Performance Specification – Advanced Data Collection System Antenna (ADA)
3267701	RF Cabling (RFC) Control Drawing
8575373	NOAA – N, N' Command List
8575374	NOAA – N, N' Telemetry List

IS20082617	TIROS Unique Interface Specification for the Solid State Recorder [Digital Data Recorder]

NASA/GSFC

GSFC-S-480-25.1	Performance Specification for the NOAA-K, L, M, N & N-prime Satellites

3.0 SPACECRAFT / GROUND INTERFACE PERFORMANCE

3.1 Spacecraft Data Transmissions / Formats

There are eight separate data types that the spacecraft is capable of transmitting. Some of these data types are transmitted real-time, with the other data types transmitted as 'playback' data. A description of each of these data types follows. A summary of these data types is listed in **Table 3.1-1**.

Table 3.1-1 Transmitter Data Type Summary

Transmitter / Data Rate	Modulation Format	Data '0'	Data '1'
STX-1, 2, or 3	Phase Modulated		
8.32 Kbps (Real-time TIP Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
16.64 Kbps (Real-time TIP Boost Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
16.64 Kbps (Real-time AIP Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
332 Kbps (TIP Playback Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
665 Kbps (Real-time HRPT Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
1.33 Mbps (LAC Playback Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
2.66 Mbps (LAC/GAC Playback Data)	NRZ - L	-67 ˚	+ 67˚
STX - 4 (see note)	Phase Modulated		
8.32 Kbps (Real-time TIP Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
16.64 Kbps (Real-time TIP Boost Data)	Split Phase	+ 67˚ / - 67˚	- 67˚ / + 67˚
BTX - 1, 2	Phase Modulated		
8.32 Kbps (Real-time TIP Data)	Split Phase	- 67˚ / +67˚	+ 67˚ / - 67˚
VTX - 1, 2	FM modulated by 2.4 kHz subcarrier	N / A	N / A
± 17 kHz (APT Data)		Analog	Analog

Note: STX-4 is capable of transmitting the data streams as noted for STX-1, 2, 3 but, as the ascent transmitter, will not normally be used to do so.

3.1.1 Real Time TIP Data Format

The TIROS Information Processor (TIP) Format contains a multiplex of analog housekeeping data, digital housekeeping data, and low rate instrument data. The TIP format is based on a major frame, which contains 320 minor frames. The major frame permits low rate sampling of many analog and digital housekeeping data points in conjunction with 550 words per second of operational payload data. The TIP data is transmitted as a 8.32-Kbps split phase signal in real time over one of the two selectable Beacon transmitters (BTX) and it is simultaneously recorded on one of the five spacecraft Digital Data Recorders (DDR) as an NRZ-L signal. The parameters of the real time TIP orbital mode format are contained in **Table 3.1.1-1**.

Table 3.1.1-1 Real Time TIP Orbital Mode Parameters

Major Frame Rate Number of Minor Frames	 1 Major frame every 32 sec. 320 per major frame
Minor Frame Rate Number of words Format	 10 minor frames per sec. 104 words per minor frame **See Table 3.1.1-2**
Word Parameters Rate Number of bits/word Order	 1040 words per sec. 8 bit 1 = MSB / bit 8 = LSB
Bit Parameters Rate Format Data 0 Data 1	 8320 bps Split phase -67° / + 67° + 67° / -67°

Table 3.1.1-2 TIP Minor Frame Format

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 Plus Word Code & Meaning
Frame Sync & S/C ID	3	0 1 2	1 1 1 0 1 1 0 1 See Note 2 1 1 1 0 0 0 1 0 0 0 0 0 A A A A See Note 1
Status	1-	3	Bit 1: Cmd Verification Status ; 1 = CV update word present in frame; 0 = no CV update in frame. Bits 2&3 TIP status; 00 = orbital mode, 10 = CPU memory Dump Mode, 01 = Dwell Mode; 11 Boost Mode. Bits 4-6: Major Frame Count: 000 = Major Frame 0 111 = Major Frame 7; MSB first; Counter incremented every 320 minor frames.
Dwell Mode Address	1+	3 4	Bits 7&8 9 bit Dwell mode address of analog channel Bits 1-7 that is being monitored continuously 0 0 0 0 0 0 0 0 0 = Analog chan 0 See Note 2 1 1 1 1 1 1 1 1 1 = Analog chan 511
Minor Frame Counter	1+	4 5	Bit 8 0 0 0 0 0 0 0 0 0 = Minor Frame 0 See Note 2 Bits 1-8 1 0 0 1 1 1 1 1 1 = Minor Frame 319
Command Verification	2	6 7	Bits 9 thru 24 of each valid received or stored command word are placed in the 16 bit slots of telemetry words 6 and 7 on a one-for-one basis . See Note 3
Time Code	5	8,9 9 9,10,11 12	9 bits of Binary Day Count, MSB first Bits 2-5: 0 1 0 1, Spare bits 27 bits of Binary millisec of Day Count, MSB first Time code is inserted in word location 8-12 only in minor frame 0 of every major frame. The data inserted is referenced to the beginning of the first bit of the minor frame sync word of minor frame 0 within ±1 millisecond.

Digital B Subcom-1	1	8	A subcommutation of Discrete Inputs collected to form 8-bit words. 256 Discrete inputs (32 words) can be accommodated. It takes 32 minor frames to sample all inputs once (sampling rate = once per 3.2 sec). A Major frame contains 10 complete Digital B subcommuted frames.
32 Sec Analog Subcom	1	9	A subcommutation of up to 191 analog points sampled once every 32 seconds plus 64 analog points sampled twice every 32 seconds (once every 16 seconds). Bit 1 of each word represents 2560 mV while Bit 8 represents 20 mV.
16 Sec Analog Subcom-1	1	10	This subcom is controlled by a PROM located in the TIP and contains 160 word locations with 128 analog channels sampled once every 16 seconds.
1 Sec Analog Subcom	1	11	This subcom is controlled by a PROM located in the TIP and contains 10 analog channels sampled once every 1 second. Word 0 of this subcom is filled with data from an analog point selected by command. The selected analog point may be any of the 512 analog points available to the TIP. Bit 1 of each word represents 2560 mV while Bit 8 represents 20 mV.

Table 3.1.1-2 TIP Minor Frame Format (Continued)

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 Plus Word Code & Meaning
Dig B Subcom-2	1	12	A subcommutation of discrete inputs collected to form 8-Bit words. 256 discrete inputs (32 words) can be accommodated. It takes 32 minor frames to sample all inputs once (sampling rate = once per 3.2 sec). A major frame contains 10 complete Digital B subcommuted frames. 64 of these Bit locations corresponding to TIP minor frames 24-31 form the XSU Digital A data. The XSU generates an 8-word subcom, which is read out at the rate of one word per minor frame. The XSU subcom is synchronized with its word 1 in minor frame 24.
16 Sec Analog Subcom-2	1	13	This subcom is controlled by a PROM located in the TIP and contains 160-word location with 128 analog channels sampled once every 16 seconds. The remaining 32 word locations contain data from the Solar Array Telemetry Commutator Unit (SATCU). The SATCU receives inputs from 16 sources on the solar array, commutates them and presents this output to the TIP on channel 282. The TIP formats this stream and presents it in the last 32 word locations. The 32 words represent two successive passes through the SATCU subcom.
DAU-1	1	14	8-bit Housekeeping Telemetry words are formed by the DAU-1 and read out by the telemetry system at an average rate of 10 words per second.
DAU-2	1	15	8-bit Housekeeping Telemetry words are formed by the DAU-2 and read out by the telemetry system at an average rate of 10 words per second.
HIRS/3	36	16, 17, 22, 23, 26, 27, 30, 31, 34, 35, 38, 39, 42, 43, 54, 55, 58, 59, 62, 63, 66, 67, 70, 71, 74, 75, 78, 79, 82, 83, 84, 85, 88, 89, 92, 93	8-bit words are formed by the HIRS/3 experiment and are read out by the telemetry system at an average rate of 360 words per second.
SEM	2	20,21	8-bit words are formed by the SEM sensor and read out by the telemetry system at an average rate of 20 words per second.
DCS-2 -- (NOAA-N) ADCS -- (NOAA-N')	32	18,19,24,25 28,29,32,33 40,41,44,45 52,53,56,57 60,61,64,65 68,69,72,73 76,77,86,87 ,90,91,94, 95	8-bit words are formed by the DCS /ADCS experiment and read out by the telemetry system at an average rate of 320 words per second.
SBUV/2	4	36, 37, 80, 81	8-bit words are formed by the SBUV/2 experiment and read out by the telemetry system at an average rate of 40 words per second.

Table 3.1.1-2 TIP Minor Frame Format (Continued)

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 Plus Word Code & Meaning
CPU A TLM	6	46, 47, 48, 49, 50, 51	A block of three 16-Bit CPU words read out by the telemetry system every minor frame.
CPU B TLM	6	96, 97, 98, 99, 100, 101	A second block of three 16-Bit CPU words read out by the telemetry system every minor frame.
MIU Status	1	102	A cycle of 80 words from the MIU, read four times in each major frame. Format varies as a function of MIU mode commanded.
CPU Data Status	1-	103	Bits 1&2: 00 = All CPU data received 01 = All CPU-A data received; CPU-B incomplete 10 = All CPU-B data received; CPU-A incomplete 11 = Both CPU-A and CPU-B incomplete
Parity	1-	103	Bit 3: Even parity check on words 2 thru 18 Bit 4: Even parity check on words 19 thru 35 Bit 5: Even parity check on words 36 thru 52 Bit 6: Even parity check on words 53 thru 69 Bit 7: Even parity check on words 70 thru 86 Bit 8: Even parity check on words 87 thru bit 7 of word 103

Notes:

1] The last 4 bits of word 2 are used for spacecraft ID

2] MSB is first

3] A complete explanation of command verification error messages is contained in Paragraphs 3.2.1.2.3.2.6 and 3.2.1.2.3.2.7 of PS-2285212.

3.1.2 Real Time AIP Data Format

The AIP Format contains a multiplex of TIP and AIP data. The AIP format is based on a major frame, which contains 80 minor frames, merged, frame for frame, with TIP and provides four major frames for each TIP major frame. The AIP data may be transmitted as a split phase signal in real time over any of the L/S Band transmitters (STX). The key parameters of the real time AIP orbital mode format are contained in **Table 3.1.2-1**.

Table 3.1.2-1 Real Time AIP Orbital Mode Parameters

Major Frame Rate Number of Minor Frames	 1 Major frame every 8-sec. 80 per major frame
Minor Frame Rate Number of words Format	 10 minor frames per sec. 208 words per minor frame **See Table 3.1.2-2**
Word Parameters Rate Number of bits/word Order	 2080 words per sec. 8 bit 1 = MSB / bit 8 = LSB
Bit Parameters Rate Format Data 0 Data 1	 16,640 Split phase -67° / + 67° + 67° / -67°

3.1.3 Playback TIP Data Format

The playback TIROS Information Processor (TIP) format is a speeded up, time reversed replica of the real-time TIP data. The data is transmitted at 0.332 Mbps, which is approximately 40 times the recorded bit rate. On playback, the recorded NRZ-L data is transformed into a split phase data stream and then used to modulate an STX. The key parameters of the playback TIP format are contained in **Table 3.1.3**.

Historically, the NOAA - TIROS Data Handling Subsystem has stored TIP, AIP, GAC, and LAC on multi-speed, multi-track digital tape recorders. Because of the differing bit rates of these data products, four recording and three playback speeds are provided. However, these speeds are not interchangeable for any specific format. The system is implemented with all record operations in the forward direction, and playback in reverse, at the appropriate speed for each format. Fast Forward wind is provided in the tape recorders to allow the tape to be positioned for a second playback if necessary. This function is provided by the Jump to End of File (EOF) command in the (Solid State) Digital Data Recorders of NOAA-NN'. The Fast Forward command will still operate, but is unnecessary. By design, there is no intent to provide data recovery capability in the forward direction. If users wish to attempt forward data recovery, no harm will occur to the recorder, but only the 2.66 MHz clock rate is available. Since this is not a system design specification, full functional testing is not provided at the spacecraft level.

3.1.4 Playback AIP Data Format

The playback AMSU Information Processor (AIP) format is a speeded up, time reversed replica of the real-time AIP data. The data is transmitted at 0.332 Mbps, which is approximately 20 times the recorded bit rate. On playback, the recorded NRZ-L data is transformed into a split phase data stream and then used to modulate an STX. The key parameters of the playback AIP format are contained in **Table 3.1.4**.

Table 3.1.2-2 AIP Minor Frame Format

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 Plus Word Code & Meaning
Frame Sync	3	0 1 2	1 1 1 1 0 0 1 1 0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 See Note
Spare	1	3	0 1 0 1 0 1 0 1
Minor Frame Counter	1	4	0 0 0 0 0 0 0 0 Represents Minor Frame 0 0 1 0 0 1 1 1 1 Represents Minor Frame 79 MSB is First
Major Frame Counter	1	5	First six Bits are 0 0 0 0 0 0. Last two Bits are major (8-sec) frame counter. The major frame counter is incremented every 80 minor frames. Bits 7 and 8 of minor frame 5 will count 8-second intervals, the count overflowing to 0 synchronous with the TIP 32-second major frame pulse.
MIU / MHS Housekeeping	2	6 7	8-bit words formed by the MIU to record status of the MHS and the MIU and read by the AMSU Information Processor at an average rate of 20 words per second.
AMSU-A1	26	8 thru 33	8-bit words are formed by the AMSU-A1 experiment and are read out by the AMSU Information Processor at an average rate of 260 words per second.
AMSU-A2	14	34 thru 47	8-bit words are formed by the AMSU-A2 experiment and are read out by the AMSU Information Processor at an average rate of 140 words per second.
MHS	54	48 thru 101	8-bit words are formed by the MHS experiment and are read out by the AMSU Information Processor through the MHS Interface Unit at an average rate of 540 words per second.
AMSU Parity	1	102	Bit 1: 0 Bit 2: 1 Bit 3: Even parity check on words 2 through 18 Bit 4: Even parity check on words 19 through 35 Bit 5: Even parity check on words 36 through 52 Bit 6: Even parity check on words 53 through 69 Bit 7: Even parity check on words 70 through 86 Bit 8: Even parity check on words 87 through Bit 7 of Word 102
TIP Data	104	103 thru 206	Identical to TIP minor frame format contained in **Table 3.1.1-2.**
TIP Parity	1	207	Bit 1: 0 Bit 2: 1 Bit 3: Even parity check on words 105 through 121 Bit 4: Even parity check on words 122 through 138 Bit 5: Even parity check on words 139 through 155 Bit 6: Even parity check on words 156 through 172 Bit 7: Even parity check on words 173 through 189 Bit 8: Even parity check on words 190 through Bit 7 of Word 206 This parity word amounts to an AIP recalculation of the TIP parity, which was calculated by the TIP in TIP word 103 (AIP word 206).

Note: Frame sync is first 22 bits. Last 2 bits of word 2 are: 00.

Table 3.1.3 Playback TIP Orbital Mode Parameters

Major Frame Rate Number of Minor Frames	 1.25 X (3327 / 3328) major frames / sec 320
Minor Frame Rate Number of words Format	 400 minor frames / sec (approx.) 104 Time reversed image of format in **Table 3.1.1-2**
Word Parameters Rate Number of bits/word Order	 41600 words / sec (approx.) 8 Bit 1 = MSB / Bit 8 = LSB
Bit Parameters Rate Format Data 0 Data 1	 332700 Bits/sec. Split phase + 67° / - 67° - 67° / +67°

Table 3.1.4 Playback AIP Orbital Mode Parameters

Major Frame Rate Number of Minor Frames	 2.5 X (3327 / 3328) major frames/sec 80
Minor Frame Rate Number of words Format	 200 minor frames / sec (approx.) 208 Time reversed image of format in **Table 3.1.1-2**
Word Parameters Rate Number of bits/word Order	 41600 words / sec (approx.) 8 Bit 1 = MSB / Bit 8 = LSB
Bit Parameters Rate Format Data 0 Data 1	 332700 Bits / sec. Split phase + 67° / - 67° - 67° / +67°

3.1.5 HRPT Format

The High Rate Picture Transmission (HRPT) Format provides a major frame, which is made up of 3 minor frames. TIP and AMSU/MHS data are updated at the major frame rate. That is, the three minor frames, which make up a major frame, will contain TIP data in the first minor frame, backfill in the second minor frame, and AMSU/MHS data in the third minor frame. The HRPT is provided in a split phase format to the S-Band Transmitter. The split phase data ‘0’ is defined as being +67° phase during the first half of the bit period and -67° phase during the second half of the bit period. The split phase data ‘1’ is defined as being -67° phase during the first half of the bit period and +67° phase during the second half of the bit period. The time code contained in each minor frame indicates the spacecraft time 1.13 ±0.5 milliseconds before the beginning of bit 1 of word 1. The HRPT parameters are given in **Table 3.1.5-1** and the HRPT minor frame format is shown in **Table 3.1.5-2.**

Table 3.1.5-1 HRPT Parameters

Major Frame Rate Number of Minor Frames / major Frame	 2 major frames / sec 3
Minor Frame Rate Number of words Format	 6 minor frames / sec 11090 **See Table 3.1.5-2**
Word Parameters Rate Number of bits / word Order	 66540 words / sec 10 Bit 1 = MSB / Bit 10 = LSB
Bit Parameters Rate Format Data 0 Data 1	 665400 Bits / sec. Split phase + 67° / - 67° - 67° / +67°

Table 3.1.5-2 HRPT Minor Frame Format

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 9 10 Plus Word Code & Meaning
Frame Sync	6	1 2 3 4 5 6	1 0 1 0 0 0 0 1 0 0 0 1 0 1 1 0 1 1 1 1 1 1 0 1 0 1 1 1 0 0 See Note 1 0 1 1 0 0 1 1 1 0 1 1 0 0 0 0 0 1 1 1 1 0 0 1 0 0 1 0 1 0 1
ID	2	7 8	Bit 1; 0 = Internal Sync; 1 = AVHRR Sync Bits 2 & 3; 00 = Not an HRPT frame but a GAC Frame; 01 = Minor Frame #1; 10 = Minor Frame #2, 11 = Minor Frame #3 Bits 4-7; Spacecraft Addresses; Bit 4 = MSB, Bit 7 = LSB Bit 8; 0 = Frame Stable; 1 = Frame Resync Occurred Bit 9; 1 = Normal AVHRR input; 0 = PN AVHRR input Bit 10; 0 = AVHRR CH3A, 1 = AVHRR CH3B Bits 1-10; Spare - undefined
Time Code	4	9 10 11 12	Bits 1-9; Binary day count; Bit 1 = MSB; Bit 9 = LSB Bit 10; 0; spare Bit 1-3; 101, spare Bits 4-10; Part of Binary msec of day count; Bit 4 = MSB Bit 1-10; Part of Binary msec of day count; Bit 1-10; Remainder of Binary msec of day count; Bit 10 = LSB
Telemetry	10	13 14 15 16 17 18 19 20 21 22	Ramp Calibration AVHRR Channel #1 Ramp Calibration AVHRR Channel #2 Ramp Calibration AVHRR Channel #3 Ramp Calibration AVHRR Channel #4 Ramp Calibration AVHRR Channel #5 AVHRR Chan #3 Target Temp. AVHRR Chan #4 Target Temp. AVHRR Chan #5 Target Temp. See Note 2 Channel 3 patch Temp. Spare - Undefined
Back Scan	30	23 thru 52	10 words of back scan data from each AVHRR channel 3, 4, and 5. These data are time multiplexed as chan 3 (word 1), chan 4 (word 1), chan 5 (word 1), chan 3 (word 2), chan 4 (word 2), chan 5 (word 2), etc.
Space Data	50	53 thru 102	10 words of space scan data from each AVHRR channel 1, 2, 3, 4, and 5. These data are time multiplexed as chan 1 (word 1), chan 2 (word 1), chan 3 (word 1), chan 4 (word 1), chan 5 (word 1), chan 1 (word 2), chan 2 (word 2), chan 3 (word 2), chan 4 (word 2), chan 5 (word 2), etc.
Sync Delta	1	103	Bit 1; 0 = AVHRR sync early; 1 = AVHRR sync late, Bits 2-10; 9 bit binary count of 0.9984 MHz periods; Bit 2 = MSB, Bit 10 - LSB

Table 3.1.5-2 HRPT Minor Frame Format (Continued)

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 9 10 Plus Word Code & Meaning
Data Words	520	104 thru 623	3 sets of data corresponding to three HRPT minor frames per HRPT major frame. First HRPT minor frame: The 520 words contain 5 TIP minor frames of TIP data (104 TIP data words per TIP minor frame) Bits 1-8: Exact format as generated by TIP. Bit 9: Even parity check over Bits 1-8. Bit 10: Inverted Bit 1. Second HRPT minor frame: The 520 words shall consist of five frames (104 words per frame) of spare data in the same form as spare words 624-750. Third HRPT minor frame: The 520 words shall consist of five frames (104 words per frame) of AMSU/MHS data from the AIP. Bits 1-8: Exact format as generated by AIP. Bit 9: Even parity check over Bits 1-8. Bit 10: Inverted Bit 1. See Note 3
Spare Words	127	624 625 626 627 628 thru 748 749 750	0 1 0 0 0 0 1 0 0 1 0 1 1 1 1 0 1 1 1 0 1 1 1 0 1 0 1 0 1 0 0 0 1 1 1 0 1 1 1 0 0 0 1 0 1 1 0 0 0 0 thru See Note 4 1 0 1 1 0 1 1 1 0 1 0 0 0 1 0 0 1 1 1 0 1 1 1 1 0 0 1 0 0 1
Earth Data	10,240	751 752 753 754 755 756 thru 10,985 10,986 10,987 10,988 10,989 10,990	Chan 1 - Sample 1 Chan 2 - Sample 1 Chan 3 - Sample 1 Chan 4 - Sample 1 Chan 5 - Sample 1 Chan 1 - Sample 2 thru See Note 5 Chan 5 - Sample 2047 Chan 1 - Sample 2048 Chan 2 - Sample 2048 Chan 3 - Sample 2048 Chan 4 - Sample 2048 Chan 5 - Sample 2048
Auxiliary Sync	100	10,991 10,992 10,993 10,994 thru 11,089 11,090	1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 0 0 1 1 0 1 1 0 1 1 0 1 0 1 1 0 1 0 1 1 1 1 0 1 thru See Note 6 0 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 1 1 0 0

Notes:

1] First 60 bits from a 63 bit PN generator started in the all '1's state.

The generator polynomial is $X^6 + X^5 + X^2 + X + 1$ **(See Figure 3.1.5)**

2] Each of these words is a 5 channel subcom; 4 words of IR data plus subcom sync (10 '0's)

3] The 104th word of each AMSU/MHS data frame to the MIRP contains 1110110100.

4] Derived by inverting the output of a 1023 Bit PN sequence provided by a feedback shift register generating the polynomial:

$X^{10} + X^5 + X^2 + X + 1$ **(See Figure 3.1.5)**

The generator is started in all 1's state at the beginning of word 7 of each minor frame.

5] Each minor frame contains the data obtained during one Earth scan of the AVHRR sensor. The data from the five sensor channels of the AVHRR are time multiplexed as indicated.

6] Derived from the non-inverted output of a 1023 bit PN sequence provided by a feedback shift register generating the polynomial:

$X^{10} + X^5 + X^2 + X + 1$ **(See Figure 3.1.5)**

The generator is started in the all 1's state at the beginning of word 10,991

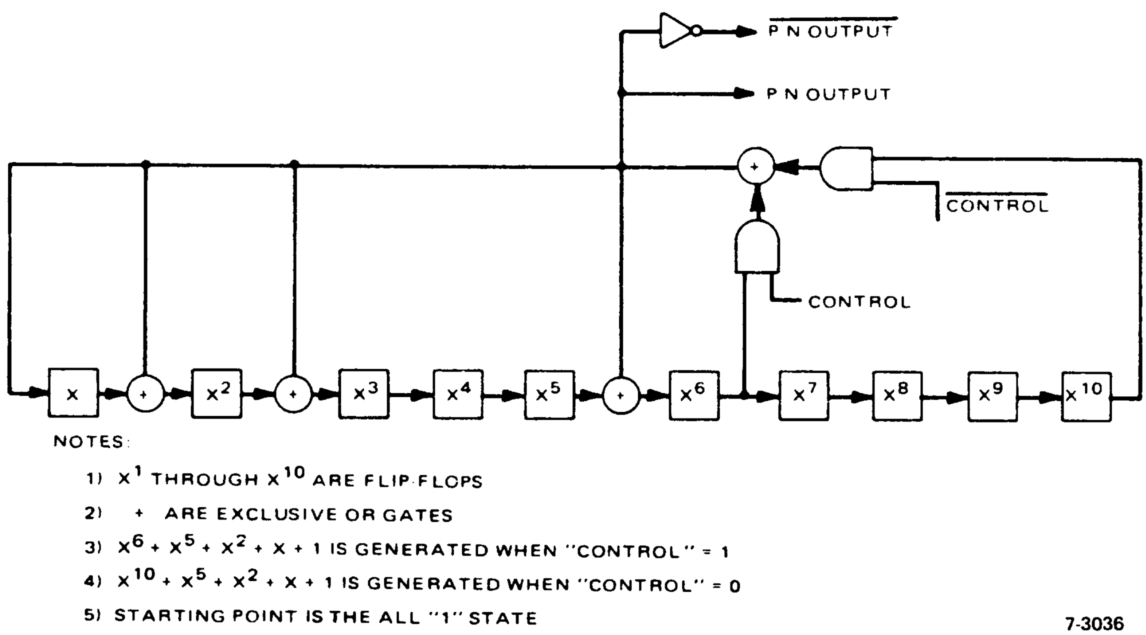


Figure 3.1.5 Sixth and Tenth Degree Polynomial Generators

3.1.6 LAC Format

Local Area Coverage (LAC) data is recorded on one of the five spacecraft digital data recorders and then played back through an STX. The LAC Format parameters are shown in **Table 3.1.6.** The LAC Minor Frame Format is identical to that described in **Table 3.1.5-2** (HRPT) except as delineated in Item 4. The time code contained in each minor frame indicates the actual spacecraft time 1.13 ±0.5 milliseconds before the beginning of bit 1 of word 1. The following summarizes the major aspects of LAC data.

1. The LAC bit rate is 1.33 Mbps or 2.66 Mbps as determined by the selected Digital Data Recorder's playback speed.
2. The LAC bit Format is NRZ-L if the playback bit rate is 2.66 Mbps or split phase if the playback bit rate is 1.33 Mbps.
3. The LAC Format is time inverted. The MSB is transmitted last and the LSB is transmitted first; the 6-word frame sync is transmitted last and the 100 word auxiliary sync is transmitted first. The (Solid State) Digital Data Recorder will permit forward playback at 2.66 MHz only. See paragraph 3.1.3.
4. The 127 spare words are Data '0' before randomizing.
5. The LAC minor frame is randomized. The randomization methodology is shown in **Figure 3.1.6**. The same 10th degree polynomial ($X^{10} + X^5 + X^2 + X+1$) generator used to provide the auxiliary sync is used to randomize the data. The complemented output of the PN generator shift register is modulo 2 added on a bit-by-bit basis to the minor frame data.

Table 3.1.6 LAC Playback Parameters

<u>Major Frame</u>		
Rate	4 or 8 major frames / sec	
Number of Minor Frames / Major Frame	3	
<u>Minor Frame</u>		
Rate	12 or 24 minor frames / sec	
Number of words	11090	
Format	Time inverted version of HRPT format. (Forward available at 2.66 MHz only, 8 major frames / sec.)	
<u>Word Parameters</u>		
Rate	133080 or 266160 words / sec	
Number of bits / word	10	
Order	Bit 1 = MSB / Bit 10 = LSB	
<u>Bit Parameters</u>		
Rate	**<u>1.33 Mbits / sec</u>**	**<u>2.66 Mbits / sec</u>**
Format	Split phase	NRZ – L
Data 0	+ 67° / - 67°	- 67°
Data 1	- 67° / +67°	+ 67°

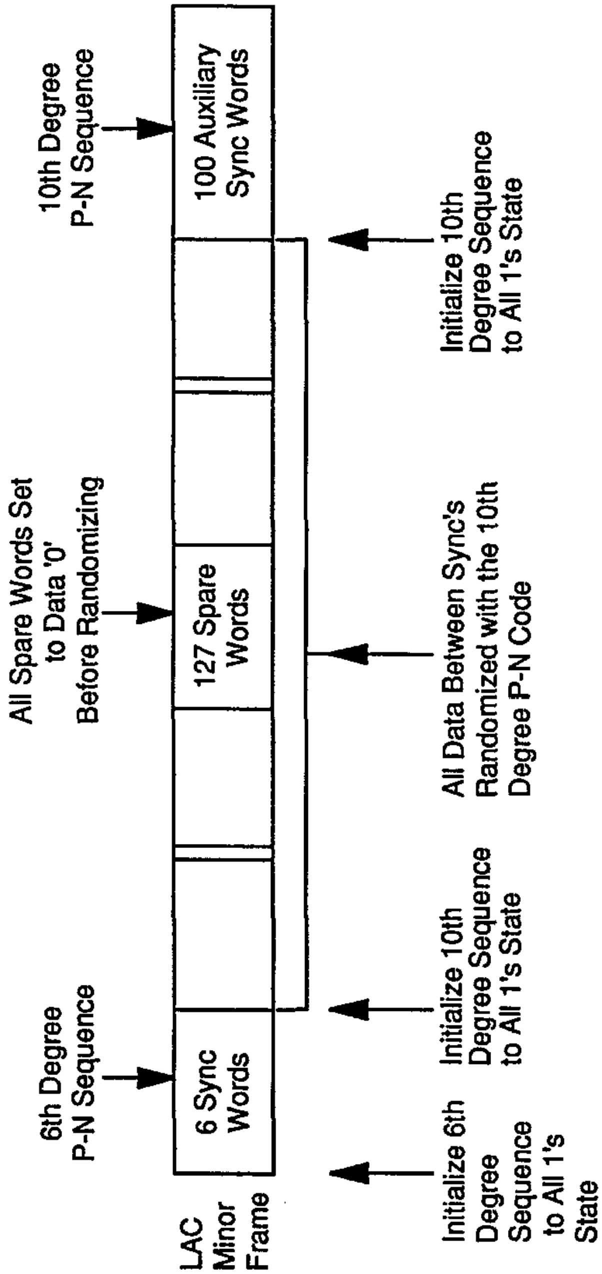


Figure 3.1.6 LAC Minor Frame Randomization Methodology

3.1.7 GAC Format

The Global Area Coverage (GAC) Format parameters are given in **Table 3.1.7-1** and **Table 3.1.7-2**. Like LAC, GAC data is recorded and then played back through an STX.

1. The GAC bit rate is 1.33 Mbps or 2.66 Mbps as determined by the selected Digital Data Recorder's playback speed.
2. The GAC bit Format is NRZ-L if the playback bit rate is 2.66 Mbps or split phase if the playback bit rate is 1.33 Mbps.
3. The GAC Format is time inverted. The MSB is transmitted last and the LSB is transmitted first; the 6-word frame sync is transmitted last and the 100 word auxiliary sync is transmitted first. The (Solid State) Digital Data Recorder will permit forward playback at 2.66 MHz only. See paragraph 3.1.3.
4) The GAC frame is randomized. The randomization methodology is shown in **Figure 3.1.7**. The same 10th degree polynomial ($X^{10} + X^5 + X^2 + X+1$) generator used to provide the auxiliary sync is used to randomize the data. The complemented output of the PN generating shift register is modulo 2 added on a bit-by-bit basis to the GAC.
5) The time code contained in each GAC Frame indicates the actual spacecraft time 1.13 ±0.5 milliseconds before the beginning of bit 1 by word 1.

Table 3.1.7-1 GAC Playback Parameters

Frame		
Rate	40 or 80 frames / sec	
Number of words	3327	
Format	Time inverted version of GAC format. (Forward available at 2.66 MHz only, 80 frames / sec.)	
Word Parameters		
Rate	133,080 or 266,160 words / sec	
Number of bits / word	10	
Order	Bit 1 = MSB / Bit 10 = LSB	
Bit Parameters		
Rate	**1.33 Mbits / sec**	**2.66 Mbits / sec**
Format	Split phase	NRZ – L
Data 0	+ 67° / - 67°	- 67°
Data 1	- 67° / +67°	+ 67°

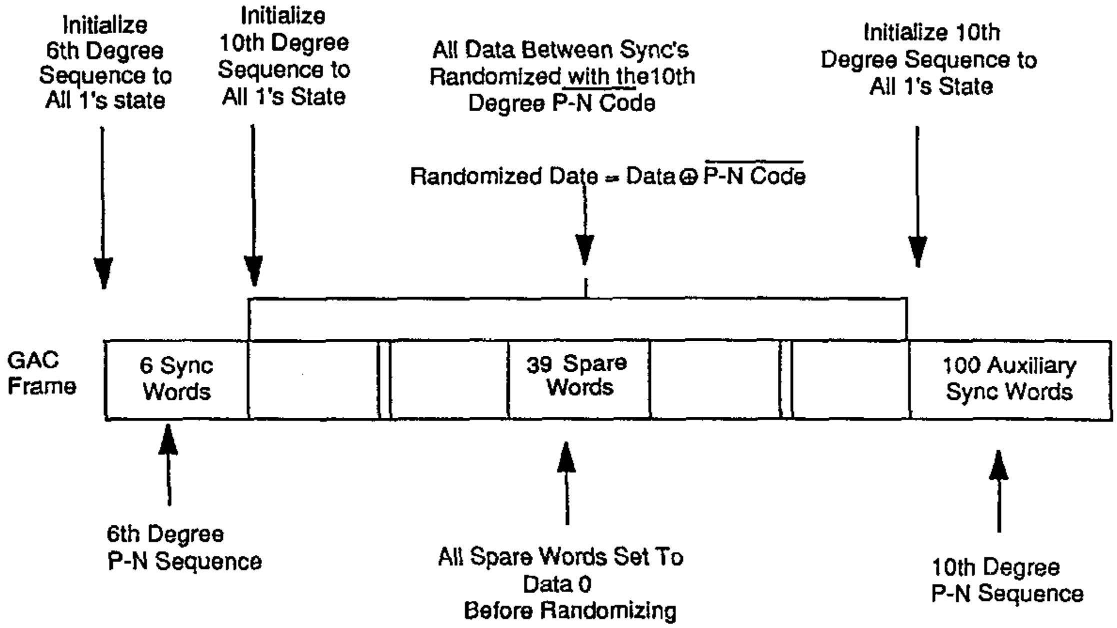


Figure 3.1.7 GAC Frame Randomization Methodology

Table 3.1.7-2 GAC Frame Format

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 9 10 Plus Word Code & Meaning
Frame Sync	6	1 2 3 4 5 6	1 0 1 0 0 0 0 1 0 0 0 1 0 1 1 0 1 1 1 1 1 1 0 1 0 1 1 1 0 0 See Note 1 0 1 1 0 0 1 1 1 0 1 1 0 0 0 0 0 1 1 1 1 0 0 1 0 0 1 0 1 0 1
ID	2	7 8	Bit 1; 0 = Internal Sync; 1 - AVHRR Sync Bits 2 & 3; 00 = Identifies Frame as GAC Frame Bits 4-7; Spacecraft Address; Bit 4 = MSB, Bit 7 = LSB Bit 8; 0 = Frame Stable; 1 = Frame Resync Occurred Bit 9; 1 = Normal AVHRR input; 0 = PN AVHRR input Bit 10; 0 = AVHRR CH3A, 1 = AVHRR CH3B Bits 1-10; Spare - undefined
Time Code	4	9 10 11 12	Bits 1-9; Binary day count; Bit 1 = MSB; Bit 9 = LSB Bit 10; 0; spare Bit 1-3; 101, spare Bits 4-10; Part of Binary msec of day count; Bit 4 = MSB Bit 1-10; Part of Binary msec of day count; Bit 1-10; Remainder of Binary msec of day count; Bit 10 = LSB
Telemetry	10	13 14 15 16 17 18 19 20 21 22	Ramp Calibration AVHRR Channel #1 Ramp Calibration AVHRR Channel #2 Ramp Calibration AVHRR Channel #3 Ramp Calibration AVHRR Channel #4 Ramp Calibration AVHRR Channel #5 AVHRR Chan #3 Target Temp. AVHRR Chan #4 Target Temp. See Note 2 AVHRR Chan #5 Target Temp. Channel 3 patch Temp. Spare - undefined
Back Scan	30	23 thru 52	10 words of back scan data from each AVHRR channel 3, 4, and 5. These data are time multiplexed as chan 3 (word 1), chan 4 (word 1), chan 5 (word 1), chan 3 (word 2), chan 4 (word 2), chan 5 (word 2), etc.
Space Data	50	53 thru 102	10 words of space scan data from each AVHRR channel 1, 2, 3, 4, and 5. These data are time multiplexed as chan 1 (word 1), chan 2 (word 1), chan 3 (word 1), chan 4 (word 1), chan 5 (word 1), chan 1 (word 2), chan 2 (word 2), chan 3 (word 2), chan 4 (word 2), chan 5 (word 2), etc.
Sync Delta	1	103	Bit 1; 0 = AVHRR sync Early; 1 = AVHRR sync Late Bit 2-10; 9 bit binary count of 0.9984 MHz periods; Bit 2 = MSB, Bit 10 = LSB
Tip Data	520	104 thru 623	The 520 words contain 5 minor frames of TIP data (104 TIP data words/frame) Bits 1-8: exact format as generated by TIP Bit 9: even parity check over bits 1-8 Bit 10: = Bit 1

Table 3.1.7-2 GAC Frame Format (Continued)

Function	No. of Words	Word Position	Bit No. 1 2 3 4 5 6 7 8 9 10 Plus Word Code & Meaning
Data Words	520 Words AMSU Data	624-1143	The 520 words shall consist of five frames (104 words per frame) of AMSU/MHS data from the AIP. Bits 1-8: Exact format as generated by AIP. Bit 9: Even parity check over Bits 1-8. Bit 10: Inverted Bit 1. See Note 3
Spare	39 Words Spare Data	1144-1182	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Processed Earth Data	2045	1183 1184 1185 1186 1187 1188 thru 3222 3223 3224 3225 3226 3227	Chan 1 - avg. sample 1 Chan 2 - avg. sample 1 Chan 3 - avg. sample 1 Chan 4 - avg. sample 1 Chan 5 - avg. sample 1 Chan 1 - avg. sample 2 thru See Note 5 Chan 5 - avg. sample 408 Chan 1 - avg. sample 409 Chan 2 - avg. sample 409 Chan 3 - avg. sample 409 Chan 4 - avg. sample 409 Chan 5 - avg. sample 409
Auxiliary Sync	100	3228 3229 3230 3231 thru 3326 3327	1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 0 0 1 1 0 1 1 0 1 1 0 1 0 1 1 0 1 0 1 1 1 1 0 1 thru See Note 6 0 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 1 1 0 0

Notes:

1] 1st 60 bits from a 63-bit PN generator started in the all 1's state.

The generator polynomial is $X^6 + X^5 + X^2 + X + 1$

2] Each of these words is a 5 channel subcom; 4 words of IR data plus subcom sync (10 '0's)

3] The 104th word of each AMSU/MHS data frame to the MIRP contains 1110110100.

4] Reserved.

5] Each GAC frame contains processed data, which is obtained from every 3rd Earth scan of the AVHRR sensor. Each "avg. sample" is the average of 4 contiguous samples obtained during each 5-sample interval for each AVHRR sensor channel. The "avg. samples" are time multiplexed as indicated.

6] Derived from the non-inverted output of a 1023 Bit PN sequence provided by a feedback shift register generating the polynomial: $X^{10} + X^5 + X^2 + X + 1$

The generator is started in the 1's state at the beginning of word 3228.

3.1.8 APT Data Format

The Automatic Picture Transmission (APT) Format is defined in **Table 3.1.8** and **Figure 3.1.8-1,** and **Figure 3.1.8-2**. The APT provides a time multiplex of geometrically corrected data from any two selected AVHRR sensor channels and includes calibrations and telemetry data associated with the selected sensor channel. After digital formatting, the MIRP D/A converts the APT data, low pass filters the D/A output, and then AM modulates a 2400 Hz subcarrier. The subcarrier modulation sense is defined as; gray scale wedge #8 produces a maximum modulation index of 87% +5%. The AM modulated subcarrier is subsequently used to FM modulate the VTX transmitter.

Table 3.1.8 APT Format Parameters

Frame	
Rate	1 frame per 64 sec
Length	128 lines
Format	**See Figure 3.1.8-1**
Line Parameters	
Rate	2 lines/sec
Number of words	2080
Number of sensor channels	any 2 of 6 AVHRR channels (selectable)
Number of words / sensor channel	909
Format	**See Figure 3.1.8-2**
Line sync format	**See Figure 3.1.8-3**
Word Parameters	
Rate	4160 words / sec
D/A conversion accuracy	The 8 MSB's of each 10 bit word

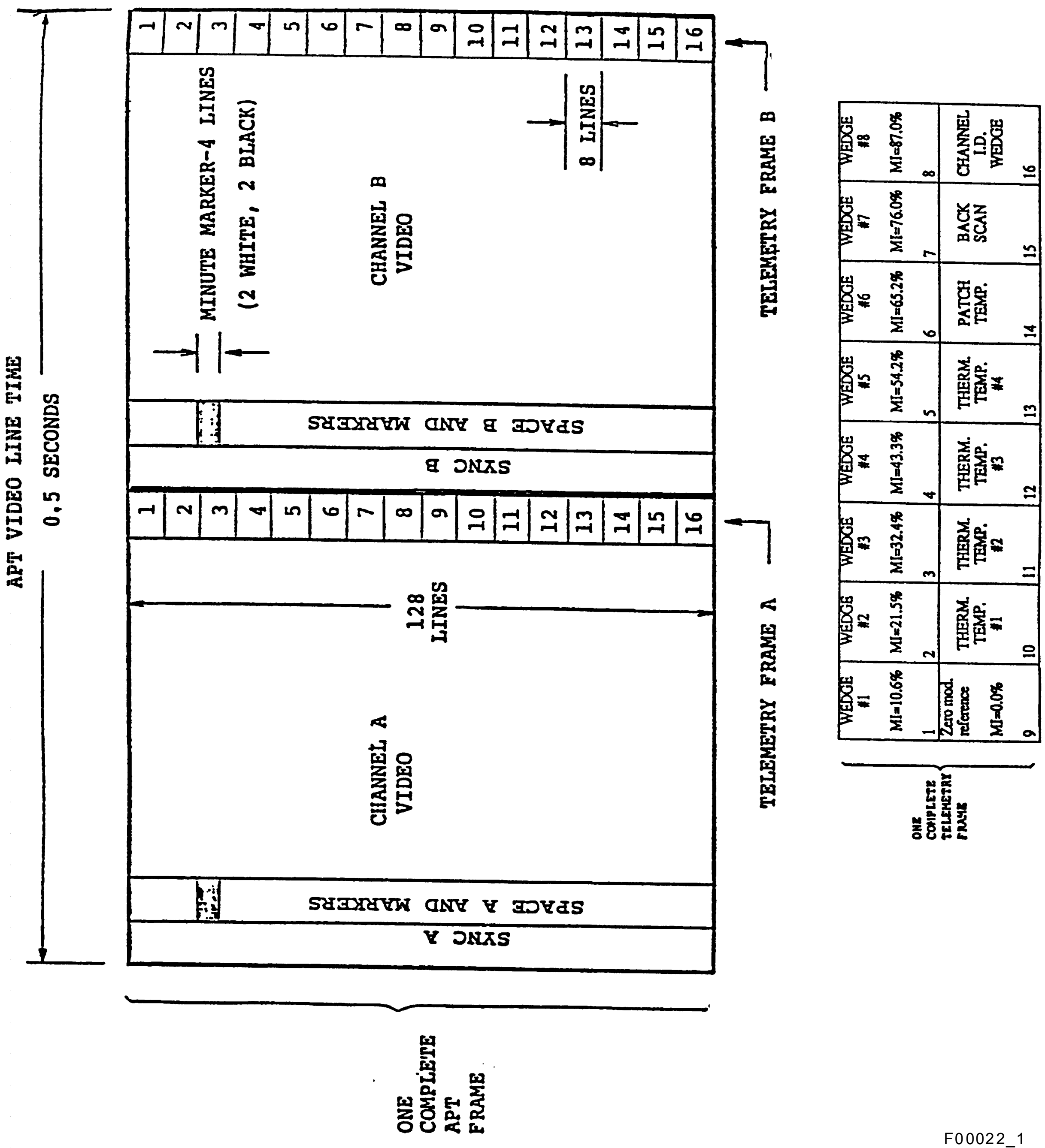
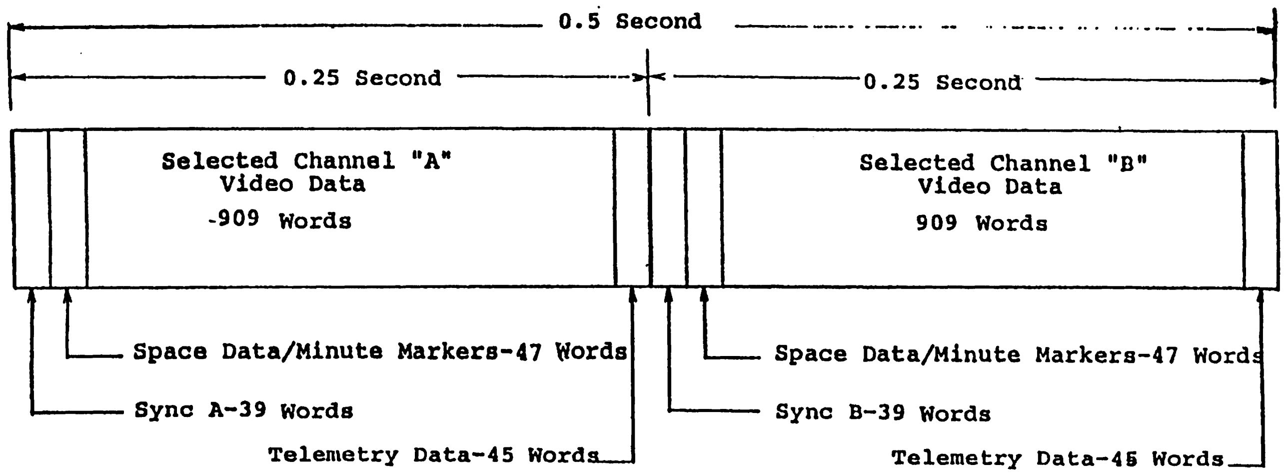


Figure 3.1.8-1 APT Frame Format

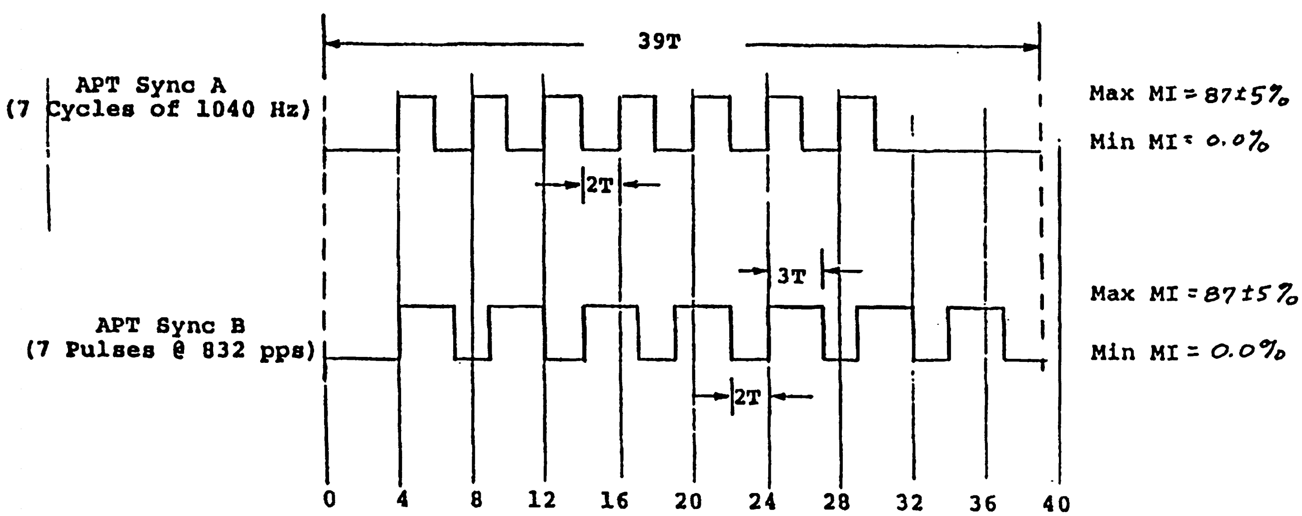


Notes:

1) Equivalent Output Digital Data Rate is 4160 Words/Second.
2) Video Line Rate - 2 Lines/Second.
3) APT Frame Size - 128 Lines.
4) Any two of the six AVHRR channels may be selected for use.
5) Sync A is a 1040-Hz square wave - 7 Cycles.
6) Sync B is a 832-pps pulse train - 7 Pulses.
7) Each of 16 telemetry points are repeated on 8 successive lines.
8) Minute markers are repeated on 4 successive lines, with 2 lines Black and 2 lines White.

F00022_2

Figure 3.1.8-2 APT Video Line Format



Notes:

1) $T = \frac{1}{4160} = 0.24038$ millisecond.
2) Sync A precedes Channel A data.
3) Sync B precedes Channel B data.

F00022_3

Figure 3.1.8-3 APT SYNC Details

3.2 Spacecraft Parameters

The following sections list the general parameters of the individual spacecraft transmitters and receivers.

3.2.1 Real Time VHF Beacon Transmitter Parameters

The spacecraft contains two VHF Real Time Beacon Transmitters (BTX). Each transmitter operates at a unique frequency; BTX-1 operates at 137.35 MHz and BTX-2 operates at 137.77 MHz. Only one BTX transmitter is selected for operation at any time, and is mission dependent. **Table 3.2.1** summarizes the BTX transmission parameters.

3.2.2 Real Time VHF APT Transmitter Parameters

The spacecraft contains two VHF Real Time Transmitters (VTX). Each transmitter operates at a unique frequency; VTX-1 operates at 137.1 MHz and VTX-2 operates at 137.9125 MHz. Only one VTX transmitter is selected for operation at any time and is mission dependent. **Table 3.2.2** summarizes the APT transmission parameters.

3.2.3 L/S-Band Transmitter Parameters

There are three L-band data transmitters (STX-1, STX-2, and STX-3) and one S-band data transmitter (STX-4) on the spacecraft. The STX transmitters are the primary source of spacecraft data transmissions. The four transmitters are capable of simultaneous operation. The STX-2 transmitter's antenna is orthogonally polarized relative to the STX-1 and STX-3 transmitters to enhance adjacent channel isolation. The RF parameters of the four STX transmitters aboard the spacecraft are summarized in **Table 3.2.3**.

Table 3.2.1 Beacon Data Transmitter (BTX) Parameters

Transmitter Frequency (MHz, ±0.002%)	137.35 (BTX-1) / 137.77 (BTX-2)
Modulation Index (rad pk-pk, ±5%)	2.35
Modulation (Kbps)	8.32
Modulation Type	Phase Mod. / Split Phase
Modulation Sense Data 0: Data 1:	 -67°/+67° +67°/-67°
Premodulation Filter (Type / 3 dB BW)	7 Pole LPF / 16 kHz
Antenna Polarization	Linear
BTX Output Power (dBm)	30.0 (EOL minimum)
Radiated Power (dBm)	$\geq$9.5 (Over 90% of sphere)

Table 3.2.2 VHF APT Data Transmitter (VTX) Parameters

Transmitter Frequency (MHz, ±0.002%)	137.10 / 137.9125 (VTX-1/VTX-2)
Modulation (AM/FM) [1]	± 17 kHz
Premodulator Bandwidth (kHz)	0.1 to 4.8
Modulation Sense	See Note 1
Antenna Polarization	RHCP
Antenna Gain (dBic)	-0.3 (@ 63˚)
VTX Output Power (dBm) [2]	37.0
S/C Losses (dB)	2.2
Radiated Power (dBm)	34.5 (@ 63˚)

Notes:

1] A 2.4-kHz subcarrier is AM modulated by a low pass filtered analog signal which subsequently FM modulates the VTX transmitter's carrier. The subcarrier's peak index of 87% ±5% corresponds to a #8 grayscale wedge. A positive voltage swing of the 2.4-kHz subcarrier induces a negative frequency shift of the transmitter.

2] Transmitter output power is End Of Life (EOL) minimum.

Table 3.2.3   S – Band Data Transmitter (STX) Parameters

Parameter	STX - 1	STX - 2	STX - 3	STX - 4
Transmitter Frequency (MHz, ±0.002%)	1698.0	1702.5	1707.0	2247.5
Modulation Index (rad pk-pk, ±5%)	2.35	2.35	2.35	2.35
Antenna Coverage (°) [1]	±63	±63/±90	±63	±90
Antenna Polarization	RHCP	LHCP / [3]	RHCP	RHCP
Antenna Ellipticity (dB)	6.0	6.0	6.0	N/A
STX Output Power (dBm) [2]	38.0	38.0	38.0	38.0
S/C Losses (dB)	0.9	1.8	0.8	5.2
S/C Antenna Gain (dBic, @ 63°)	2.1	2.1	2.1	0.0
Radiated Power (dBm, @ 63°)	39.2	38.3 / [4]	39.3	32.8 / [4]

Notes:

1] STX-1, STX-2, STX-3 are typically connected to directional antennas. STX-4 is connected to two Omni-directional antennas via a hybrid splitter with one Omni positioned in the NADIR axis and one Omni positioned in the anti-NADIR axis (both Omni antennas are RHCP polarized).

2] Transmitter output power is End Of Life (EOL) minimum

3] Transmitter STX-2 can be connected to two Omni directional antennas via a RF switch and a hybrid splitter arrangement. The NADIR Omni antenna is RHCP polarized and the anti-NADIR Omni antenna is LHCP polarized.

4] EIRP (for Omni directional configuration) is ≥ 24 dBm over 90% of a sphere for STX-2 and 95% of sphere for STX-4.

3.2.4 GSTDN Command Receiver / Demodulator Parameters

The spacecraft contains two GSTDN compatible S-Band Command Receiver/Demodulators, which are cross-strapped. Both receivers and demodulators are operated simultaneously. The parameters of the spacecraft receivers are summarized in **Table 3.2.4**.

Table 3.2.4 GSTDN Command Receiver Parameters

Center Frequency (MHz)	2026.0
Frequency Stability (%)	± 0.002
Subcarrier (kHz)	16.0 (modulation in BPSK)
Modulation Index (Rad.)	1.0 ±0.1 (for the RF carrier)
Modulation type	Phase modulated
Receiver Type	Phase Lock Loop
Received Power (dBm)	-118.0 (minimum)
Antenna (SOA-5 / -6) Polarization	RHCP

3.2.5 Data Collection System (DCS) Receiver Parameters (NOAA-N)

The Spacecraft contains a Data Collection System (DCS) receiver. Platforms (buoys, free-floating balloons and remote weather stations) collect relevant data and transmit them to the spacecraft. The onboard DCS receives the incoming signal, measures both the frequency and relative time of occurrence of each transmission and the spacecraft retransmits these data via the CDA stations. The performance characteristics of the DCS receiver are summarized in **Table 3.2.5**.

Table 3.2.5 DCS Receiver Parameters

Receiver Frequency (MHz)	401.65
Modulation Type	Phase Mod.
Dynamic Range (dBm)	-109 to -128
Receiver Losses (dB)	1.0
Antenna Polarization	RHCP

3.2.6 Search and Rescue Processor (SARP) Parameters

The spacecraft contains a Search and Rescue Processor (SARP) receiver. The performance characteristics of the SARP receiver are summarized in **Table 3.2.6**.

Table 3.2.6 SARP – 2 Parameters

Receiver Center Frequency (MHz)	406.050
Receiver 1 dB Bandwidth (kHz) Mode 1 Mode 2 Mode 3	 27 40 80
Receiver Dynamic Range (dBm)	-131 to -108
Doppler Measurement Error (Hz RMS)	0.35
Bit Error Rate	1 in 10^{10}
Output Data Rate (bps) [see note]	2409.0
Memory Capacity (Kbits)	400

Note: Output data of the SARP (2.4 Kbps) is fed to the modulator of the SARR Transmitter.

3.2.7 Search and Rescue Repeater (SARR) Parameters

The spacecraft contains a Search and Rescue Repeater (SARR). The SARR consists of redundant pairs of receivers and transmitters. Each 'side' of the SARR (Side A / Side B) consists of three separate receivers and a transmitter. The performance characteristics of the SARR receivers and transmitter are summarized in **Table 3.2.7-1** and **Table 3.2.7-2**.

Table 3.2.7-1 SARR Receiver Parameters

121.5 MHz Receiver	
Center Frequency (MHz)	121.5 ±0.0125
Dynamic Range (dBm)	-148.9 to -107.9
1 dB Bandwidth (kHz)	25
Translated Receiver Frequency (kHz)	47.0
Receiver Noise Temperature (^{o}K)	600
Maximum Input Power (dBm)	-20
Background Noise Temperature (˚K)	6000 (nominal) 10,000 (maximum)
243 MHz Receiver	
Center Frequency(MHz)	243.0 ±0.023
Dynamic Range (dBm)	-151.8 to -119.9
1 dB Bandwidth (kHz)	46
Translated Receiver Frequency (kHz)	94.0
Receiver Noise Temperature (˚K)	350
Maximum Input Power (dBm)	-20
Background Noise Temperature (˚K)	3000 (nominal)
406 MHz Receiver	
Center Frequency (MHz)	406.05 ±0.04
Dynamic Range (dBm)	-134.3 to -107.2
1 dB Bandwidth (kHz)	80
Translated Receiver Frequency (kHz)	170.0
Receiver Noise Temperature (˚K)	350
Maximum Input Power (dBm)	-20
Background Noise Temperature (˚K)	1000 (nominal)

Table 3.2.7-2 SARR Transmitter Parameters

Frequency (MHz)	1544.5
Long Term Frequency Stability (kHz)	± 3.2
Output Power (dBm)	38.6 (min Beginning of Life (BOL))
Incidental AM (max)	$\leq$ 5%
Phase Jitter (max)	10° rms

3.2.8 Advanced Data Collection System (ADCS) Receiver Parameters (NOAA-N')

The Spacecraft contains an Advanced Data Collection System (ADCS) Receiver Processing Unit (RPU). Platforms (buoys, free-floating balloons and remote weather stations) collect relevant data and transmit them to the spacecraft. The onboard ADCS receives the incoming signal, measures both the frequency and relative time of occurrence of each transmission and the spacecraft retransmits these data via the CDA stations. The performance characteristics of the ADCS receiver are summarized in **Table 3.2.8**.

Table 3.2.8 ADCS Receiver Parameters

Receiver Frequency (MHz)	401.65
Modulation Type	Phase Mod.
Dynamic Range (dBm)	-109 to -128
Receiver Losses (dB)	1.0
Antenna Polarization	RHCP

3.2.9 Advanced Data Collection System (ADCS) Transmitter Parameters (NOAA-N')

The Spacecraft contains an Advanced Data Collection System (ADCS) contains a Transmitter Unit (TXU). The TXU is used to transmit data (directives and services) to customer platforms. The performance characteristics of the ADCS transmitter are summarized in **Table 3.2.9**.

Table 3.2.9 ADCS Transmitter Parameters

Transmitter Frequency (MHz)	465.9875
Modulation Type	Phase Mod.
RF Output Power	8 Watts (39 dBm)
Data Rate	200 or 400 bps (selectable)
Antenna Polarization	RHCP

3.3 Ground System Parameters

The following sections describe the Ground Stations/Platforms that the spacecraft supports or that support the operation of the spacecraft.

3.3.1 Standard Direct Readout TIP Station Parameters

The Standard Direct Readout TIP Station receives the VHF beacon transmission, which is modulated with TIP data. The TIP data is transmitted at 8.32 Kbps, at 137.35 MHz or 137.77 MHz as selected by spacecraft command. The characteristics of the Standard Readout TIP Station are given in **Table 3.3.1**.

Table 3.3.1 Standard Direct Readout TIP Station

Received Signal from BTX	TIP
Modulation type	Split phase / Phase modulation
Bit Rate (Kbps)	8.32
Received Frequency (MHz)	137.35 or 137.77 (selectable)
Antenna polarization	Linear
Antenna Gain (dBi)	16.0

3.3.2 European TIP Dump Station Parameters

The European TIP Dump Station receives the programmed playback of stored TIP data, alternating with AIP data if selected. The stored data is transmitted at 332.7 kbps, at 1698 MHz; 1702.5 MHz; 1707 MHz, or 2247.5 MHz, depending upon the spacecraft's STX selection configuration. The characteristics of the European TIP Station are given in **Table 3.3.2**.

Table 3.3.2 European TIP Station Parameters

Received Signal from STX-1, -2 and -3	TIP Playback
Modulation type	Split phase / Phase modulation
Data rate (kbps)	332.7 Time inverted version of TIP/AIP format. (Split phase modulation available at 1.33 MHz also. NRZ-L modulated data can be commanded in either direction at a 2.66 MHz rate. However, high-speed recovery techniques shall be considered experimental until proven empirically.)
Received Frequency (MHz)	1698.0 / 1702.5 / 1707.0 / 2247.5
Antenna Polarization	RCP / LCP
Antenna Gain (dBci)	32.0
System Noise Temperature (˚K)	290

3.3.3 Standard HRPT Station Parameters

The Standard HRPT Station receives the real-time transmission of five, time – multiplexed AVHRR sensor channels. The HRPT data is transmitted at 665.4 Kpbs, at either 1698 MHz or 1707 MHz as determined by mission characteristics. The characteristics of the Standard HRPT Station are given in **Table 3.3.3**.

Table 3.3.3 Local User HRPT Station

Frequency (MHz)	1698.0 / 1707.0
Antenna Polarization	RHCP
Modulation Type	Phase Modulation
Bit Rate (Kbps)	665.4
Antenna Gain (dBci)	31.0
System Noise Temperature (˚K)	280

3.3.4 Standard APT Station Parameters

The Standard Automatic Picture Transmission (APT) Station receives the VHF real-time transmission, which is modulated with any selected two of the five AVHRR sensor channels. The two selected channels are processed in the spacecraft to produce a nearly constant ground resolution signal and are time multiplexed on a line-by-line basis. The APT data is transmitted by one of two selectable VHF (137.10 MHz or 137.9125 MHz) FM transmitters. The characteristics of the standard APT station are given in **Table 3.3.4**.

Table 3.3.4 Standard APT Local User Station

Frequency (MHz)	137.10 or 137.9125
Antenna Polarization	RHCP
Modulation Type	AM / FM
Subcarrier (kHz)	2.4
Antenna Gain (dBci)	10.0
System Noise Temperature (˚K)	3460

3.3.5 Standard DCS / ADCS Platform Parameters

The 401.65 MHz UHF band is used for Data Collection System (DCS) / Advanced Data Collection System (ADCS) transmission. The Standard DCS / ADCS Platform typically transmits for 390 milliseconds every 20 to 30 seconds. The characteristics of the Standard DSC / ADCS Platform are summarized in **Table 3.3.5**.

3.3.6 Standard SARP / SARR 406 Beacon Parameters

The 406.05 MHz UHF band is used for SARP/SARR transmission. The Standard UHF Emergency Position Indicating Radio Beacon (EPIRB) used on marine vehicles, and the Emergency Location Transmitter (ELT) used on aircraft, have the identical characteristics. The SARP/SARR Platform typically transmits for 440 milliseconds every 50 seconds. The characteristics of the Standard SARP / SARR Platform are summarized in **Table 3.3.6**.

3.3.7 Standard SARR 121 / 243 Platform Parameters

The 121.5 MHz / 243.0 MHz VHF band is used for SARR transmission. The Standard 121.5 MHz / 243 MHz SARR Platforms typically transmits continuously. The characteristics of the Standard SARR Platform are summarized in **Table 3.3.7**.

3.3.8 Standard SARR LUT Reception Parameters

The standard Search and Rescue Local User Terminal (LUT) receives the L-Band real time search and rescue signal transmitted from the spacecraft. The received signal is processed by the LUT to determine the location and identification of marine and aircraft vessels in distress. The characteristics of the standard LUT are summarized in **Table 3.3.8**.

3.3.9 NOAA CDA Station Parameters

There are two NOAA Command and Data Acquisition (CDA) stations: Wallops Island, Virginia and Fairbanks, Alaska. The CDA stations receive stored LAC/GAC data, stored TIP/AIP data, Real Time HRPT data, real time TIP data and transmit commands. The CDA ground system receiving parameters are listed in **Table 3.3.9-1** and transmitting parameters in **Table 3.3.9-2**. Each CDA is capable of full duplex operation with its command transmissions and any or all data receivers. On those orbits when a spacecraft is simultaneously in view of both CDAs, normal operations protocol shall prevent that spacecraft from being illuminated simultaneously by RF uplink transmissions from the two CDA stations. **Figures 3.3.9-1, 3.3.9-2, 3.3.9-3** and **3.3.9-4** show the antenna coverage including mechanical limits and terrain limitations for the Wallops Island and Fairbanks CDAs.

Table 3.3.5 Standard DCS / ADCS Platform Parameters

Frequency (MHz) Accuracy (kHz over 5 yr.) Short-term Stability (Hz) Max. rate of change (Hz / min)	401.65 ±0.012 ±4.0 ±0.4 ±0.2 (location type ‘A’ platform)
Carrier Modulation Positive phase shift Negative phase shift Transition time (microseconds)	PSK 63 ° ±5.73° 63 ° ±5.73° $100 \leq t \leq 250$
Data Modulation Bit period (msec) Data 1 Data 0 Asymmetry of 1/0 message Asymmetry of all 1 or 0 message	Split phase (Manchester code) 2.5 + phase shift at bit center – phase shift at bit center ±1% ±1.25%
Data Rate (bps) Long-term stability (bps per 1 yr.) Short-term stability (bps per 0.2-sec period)	400 ±5 ±0.4
Message Format Precursor Bit sync Frame sync Data	 68 bit times (at 0° carrier phase shift) 15 bits, all 1’s 9 bits (000101111) 56 bits (no constraints)
Transmitter Power (dBw)	3.0 ±1
Transmitter Line Loss (dB)	0.5
Antenna UDA Gain	**See Figure 3.3.5**
Antenna Feed Losses (dB)	1.0
Antenna Polarization	Linear and RHCP
Transmitted Signal	Phase Modulated / Split phase

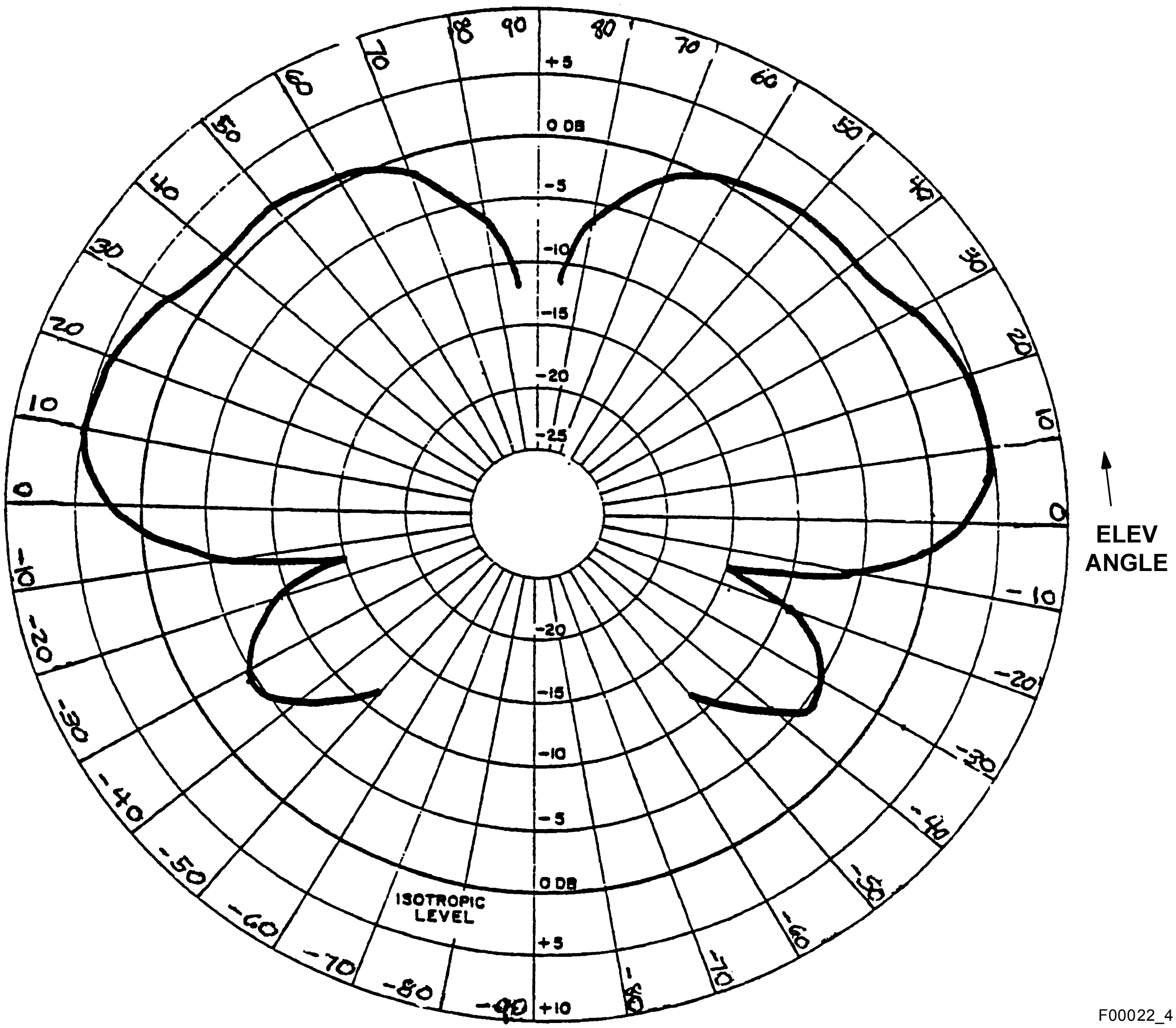


Figure 3.3.5 Standard DCS / ADCS Platform Antenna Gain

Table 3.3.6 Standard SARP / SARR (406) Beacon Parameters

Frequency (MHz) Accuracy (kHz over 5 yr.) Short-term Stability (over 100 ms) Mid-term Stability (over 15 min.)	406.05 ±2 MHz ±5.0 ≤ 2 parts in 10^9 ≤ 1 part in 10^9 (per minute)
Carrier Modulation Positive phase shift Negative phase shift	PSK 1.1 ±0.1 radian 1.1 ±0.1 radian
Data Modulation Bit period (msec) Data 1 Data 0	Biphase – L 2.5 + phase shift at bit center - phase shift at bit center
Data Rate (bps)	400 ±1%
Message Format CW Preamble Bit sync Frame sync Data	 160 ms of unmodulated carrier 15 bits, all 1's 9 bits (000101111) 112 bits standard mode 144 bits optional mode
Transmitter Power (dBw)	7.0 ±2
Antenna Polarization	Linear or RHCP
Antenna Gain	Hemispherical pattern between -3 dBi and 4 dBi over 90% of region

Table 3.3.7 Standard Search and Rescue Beacon (121 / 243) Parameters

Frequency (MHz)	121.5 ±0.005% / 243.0 ±0.005%
Beacon Output Power (dBm)	15.74
Antenna Polarization	Linear
Modulation Characteristics Emission Type Modulation Type Modulation Index Modulation Duty Cycle	 Amplitude Modulation 100% Square Wave Swept Tone ≥ 0.85% ≥ 33.3%
Occupied Bandwidth	≤ 25 kHz for 121.5, 50 kHz for 243

Table 3.3.8 Standard Search and Rescue LUT Parameters

Frequency (MHz)	1544.5 ±0.5
Received Signal	Phase Modulated
Modulation Index (rad. rms)	0.7 (composite mod.)
Polarization	LHCP
G /T (dB/K)	3.0
<u>Receiver Characteristics</u> IF Bandwidth (kHz) **<u>Repeater Baseband</u>** 121.5 MHz Ch. BW (kHz) 243.0 MHz Ch. BW (kHz) 406.0 MHz Ch. BW (kHz) Processed Data Ch. BW (kHz)	 1000 25 46 80 5
Location Processor Type	Doppler Correlator

Table 3.3.9-1 CDA Receiving Antenna Parameters

Antenna Site		Wallops Island, VA	
Antenna Size		26 Meter	
Antenna Mount		XY	
Antenna Type		Parabolic	
Antenna Feed		Prime	
Frequency (MHz)	136 - 138	1670 - 1710	2200 - 2300
Antenna Polarity	LINX/LINY	RHCP / LHCP	RHCP / LHCP
Gain (dBi) or (dBci)	27.4	43.8 / 43.6	48.7 / 48.9
3 dB Beamwidth (°)	6.7	0.54	0.34
System Noise Temperature (°K)	Unknown	343.7 / 362.7	289.8 / 323.4
G / T (dB / °K)	Unknown	18.5 / 18.0	24.0 / 23.8

Antenna Site		Wallops Island, VA	
Antenna Size		14.2 Meter	
Antenna Mount		XY	
Antenna Type		Parabolic	
Antenna Feed		Prime	
Frequency (MHz)	136 - 138	1670 - 1710	2200 - 2300
Antenna Polarity	RHCP / LHCP	RHCP / LHCP	RHCP / LHCP
Gain (dBci) or (dBci)	22.41	44.3 / 43.9	46.5 / 46.7
3 dB Beamwidth (°)	11.23	0.91	0.68
System Noise (°K)	Unknown	144.5 / 142.2	157.0 / 173.0
G / T (dB / °K)	Unknown	22.7 / 22.4	24.5 / 24.3

Table 3.3.9-1 CDA Receiving Antenna Parameters (Continued)

Antenna Site		Fairbanks, AK	
Antenna Size		26 Meter	
Antenna Mount		XY	
Antenna Type		Parabolic	
Antenna Feed		Prime	
Frequency (MHz)	136 - 138	1670 - 1710	2200 - 2300
Antenna Polarity	LINX/LINY	RHCP / LHCP	RHCP / LHCP
Gain (dBi) or (dBci)	27.4	48.7	51.8
3 dB Beamwidth (°)	6.7	0.54	0.34
System Noise (°K)	Unknown	275.4	257.0
G / T (dB / ºK)	Unknown	24.3	27.7

Antenna Site		Fairbanks, AK	
Antenna Size		12.0 Meter	
Antenna Mount		XY	
Antenna Type		Parabolic	
Antenna Feed		Prime	
Frequency (MHz)	136 - 138	1670 - 1710	2200 - 2300
Antenna Polarity	LINX / LINY	RHCP / LHCP	RHCP / LHCP
Gain (dBi) or (dBci)	16.0	43.7	46.0
3 dB Beamwidth (°)	13.0	1.0	0.8
System Noise (°K)	Unknown	813.0	426.6
G / T (dB / ºK)	Unknown	14.6	19.7

Table 3.3.9-2 CDA Transmitting Antenna Parameters

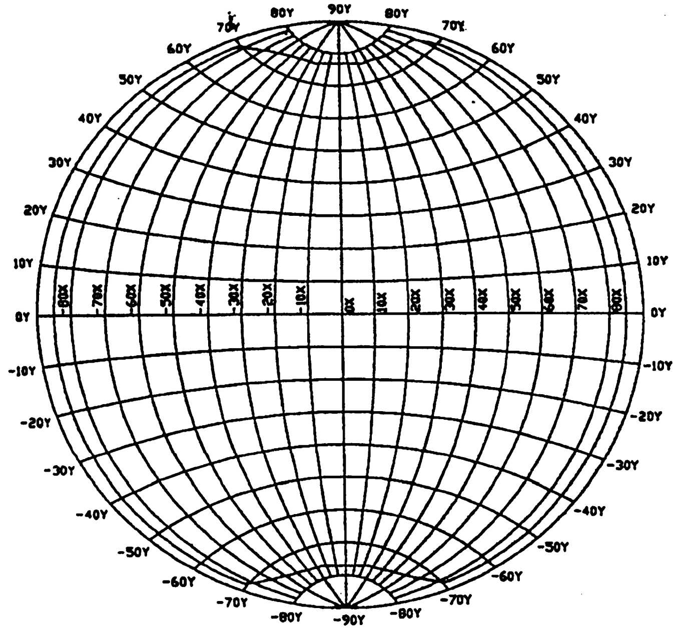
Antenna Site	Wallops Island, VA
Antenna Size	4.0 Meter
Antenna Mount	AZ/EL
Antenna Type	Parabolic
Antenna Feed	Prime
Frequency (MHz)	2024 – 2110
Antenna Polarity	RHCP
Gain (dBci)	34.0
3 dB Beamwidth (°)	3.0
Transmitter Power (KW)	2.0
EIRP (dBm)	97.0

Antenna Site	Wallops, VA
Antenna Size	14.2 Meter
Antenna Mount	XY
Antenna Type	Parabolic
Antenna Feed	Prime
Frequency (MHz)	2020 – 2120
Antenna Polarity	RHCP
Gain (dBci)	46.8
3 dB Beamwidth (°)	0.76
Transmitter Power (KW)	2.0
EIRP (dBm)	110.0

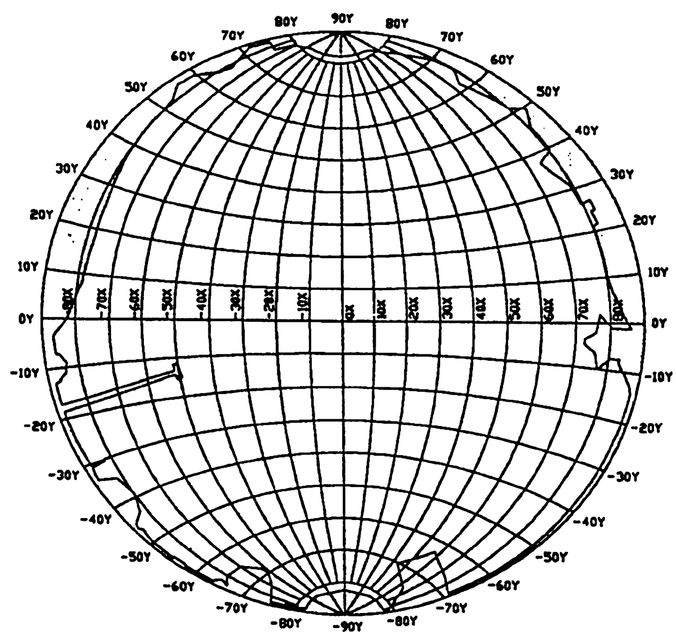
Table 3.3.9-2 CDA Transmitting Antenna Parameters (Continued)

Antenna Site	Fairbanks, AK
Antenna Size	4.0 Meter
Antenna Mount	AZ / EL
Antenna Type	Parabolic
Antenna Feed	Prime
Frequency (MHz)	2024 – 2110
Antenna Polarity	RHCP
Gain (dBci)	34.0
3 dB Beamwidth (°)	3.0
Transmitter Power (KW)	2.0
EIRP (dBm)	97.0

Antenna Site	Fairbanks, AK
Antenna Size	6.0 Meter
Antenna Mount	XY
Antenna Type	Parabolic
Antenna Feed	Prime
Frequency (MHz)	2025 – 2120
Antenna Polarity	RHCP / LHCP
Gain (dBci)	39.0
3 dB Beamwidth (°)	1.7
Transmitter Power (KW)	2.0
EIRP (dBm)	102.0



Wallops 26 Meter Antenna Horizon Profile



Wallops 14.2 Meter Antenna Horizon Profile

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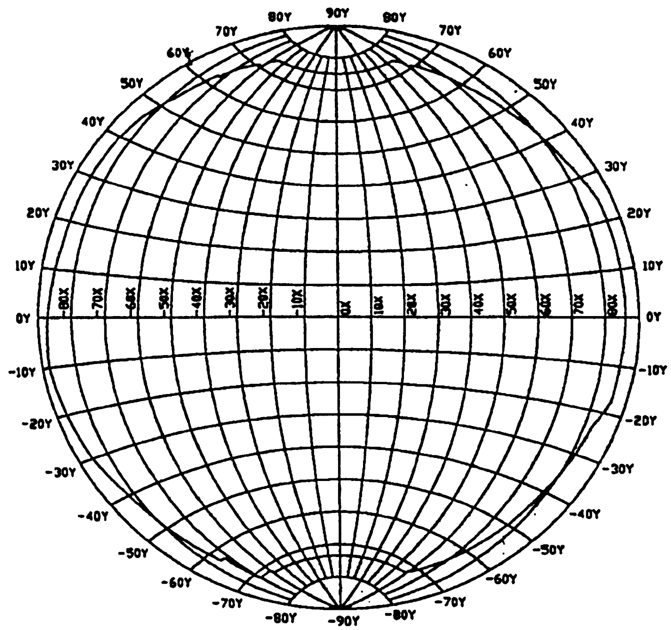
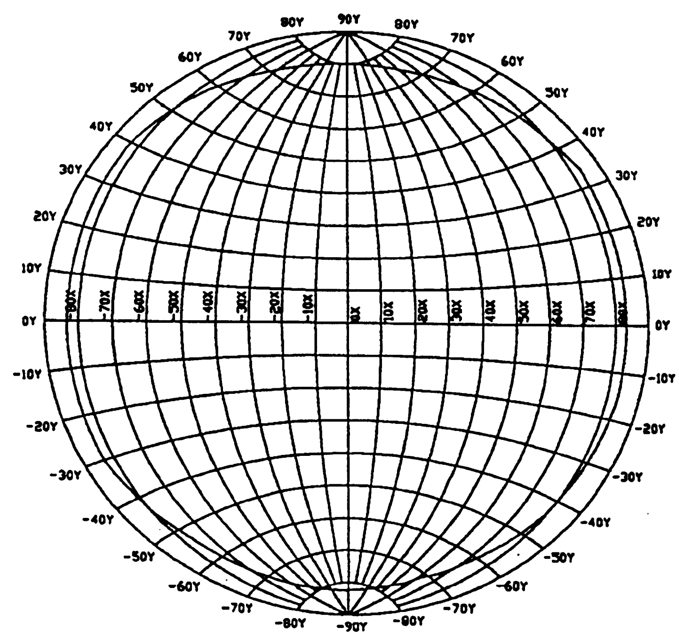
Figure 3.3.9-1 Wallops Receive Antenna's Horizon Profile



Fairbanks 26 Meter (A) Antenna Horizon Profile



Fairbanks 12 Meter (C) Antenna Horizon Profile

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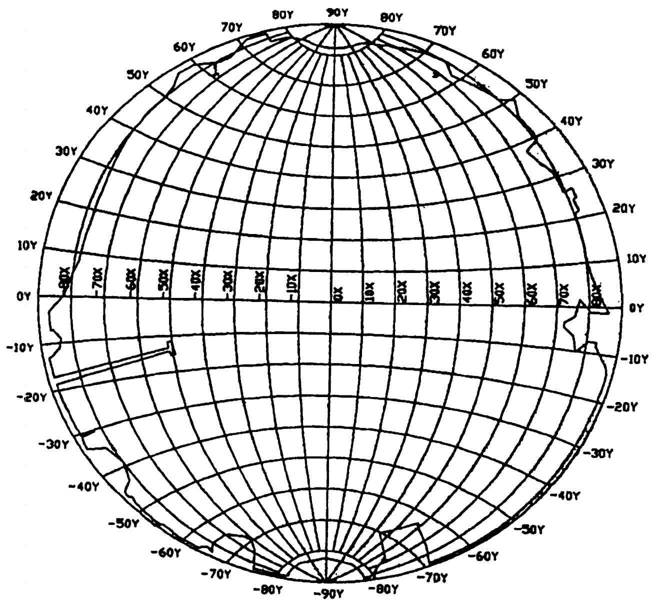
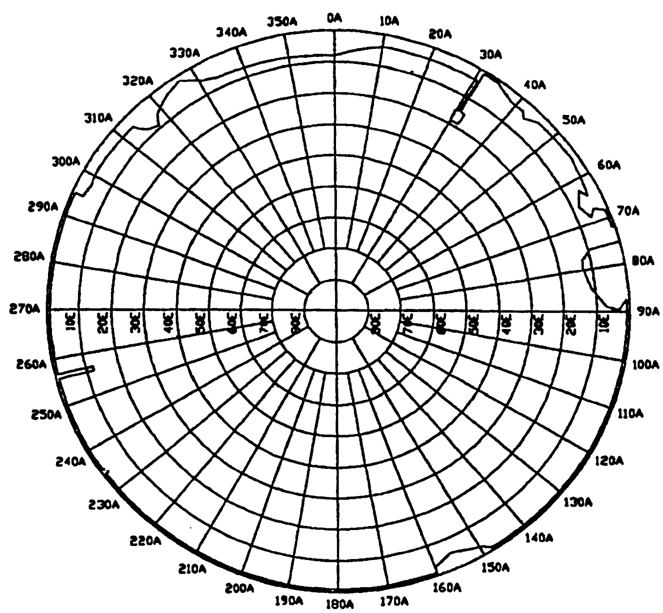
Figure 3.3.9-2 Fairbanks Receive Antenna's Horizon Profile



Wallops 14.2 Meter Antenna Horizon Profile



Wallops 4 Meter Antenna Horizon Profile

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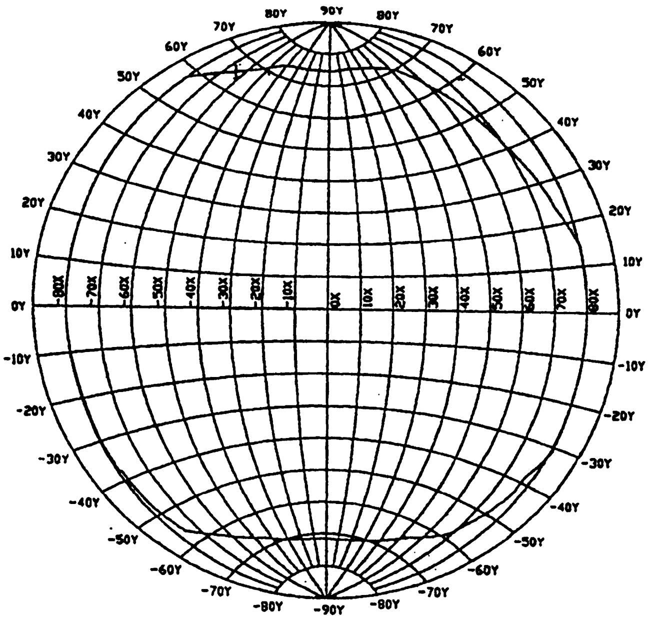
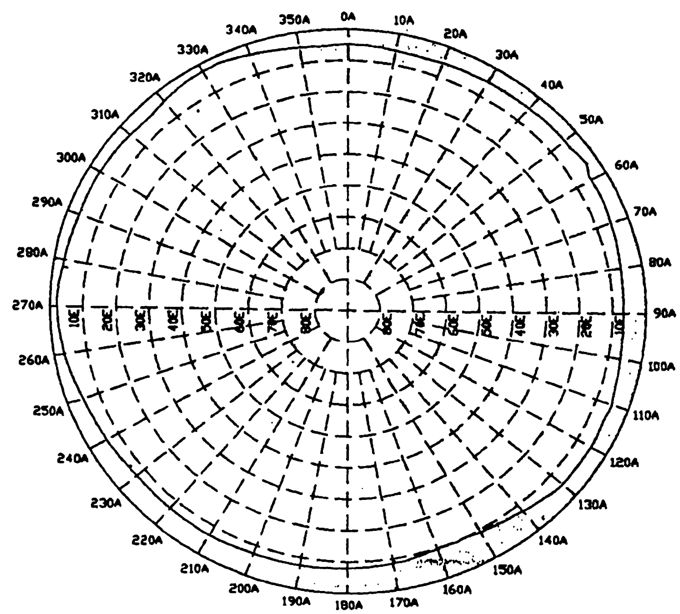
Figure 3.3.9-3 Wallops Transmitting Antenna's Horizon Profile



Fairbanks 6 Meter Antenna Horizon Profile



Fairbanks 4 Meter Antenna Horizon Profile

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Figure 3.3.9-4 Fairbanks Transmitting Antenna's Horizon Profile

3.4 Link Calculations

The following sections present the predicted performance of the various spacecraft to ground receive and transmit links.

3.4.1 Predicted Direct Readout TIP Station Performance (BTX Downlink)

Table 3.4.1 shows the predicted performance of the Direct Readout TIP station. The predicted performance was calculated using the worst case BTX output power and maximum path loss (63° spacecraft antenna angle).

Table 3.4.1 Direct Readout TIP Station Predicted Performance (BTX Downlink)

Spacecraft Radiated Power at 63° (dBm)	9.5
Path Loss at 63° (dB)	145.8
Polarization Loss (dB)	0.2
Modulation Loss (dB)	0.7
Ground Antenna Gain (dB)	16.0
Demodulator Loss (dB)	3.0
Received Level (dBm)	-124.2
Bit-Rate Bandwidth (dB-Hz) for 8.32 Kbps	39.2
Noise Density (dBm / Hz) for Ts = 1949.8 ºK	-165.7
Eb / No Required (dB) for 10^{-6} BER	10.5
Eb / No Margin (dB)	-8.2

3.4.2 Predicted European TIP Dump Station Performance (STX-2 Downlink)

Table 3.4.2 shows the predicted performance of the European TIP Playback station. The predicted performance was calculated using the worst case STX output power and maximum path loss (63° spacecraft antenna angle).

Table 3.4.2 European TIP Predicted Performance (STX-2 Downlink)

Spacecraft Radiated Power at 63° (dBm)	38.3
Path Loss at 63° (dB)	167.7
Polarization Loss (dB)	0.2
Modulation Loss (dB)	0.7
Ground Antenna Gain (dB)	32.0
Demodulator Loss (dB)	3.0
Received Level (dBm)	-101.3
Bit-Rate Bandwidth (dB-Hz) for 332 Kbps	55.2
Noise Density (dBm / Hz) for Ts = 295 ºK	-173.9
Eb / No Required (dB) for 10^{-6} BER	10.5
Eb / No Margin (dB)	6.9

3.4.3 Predicted Standard APT Station Performance (VTX Downlink)

Table 3.4.3 shows the predicted performance of the Standard APT Station. The predicted performance was calculated using the worst case VTX output power and maximum path loss (63° spacecraft antenna angle).

3.4.4 Predicted Standard HRPT Station Performance (STX Downlink)

Table 3.4.4 shows the predicted performance of the Standard HRPT Station. The predicted performance was calculated using the worst case STX output power and maximum path loss (63° spacecraft antenna angle).

3.4.5 Predicted Standard DCS / ADCS Platform Performance

Table 3.4.5 shows the predicted performance of the Standard DCS Platform reception. The predicted performance was calculated using maximum path loss (63° spacecraft antenna angle).

Table 3.4.3 Standard APT Station Predicted Performance (VTX Downlink)

Radiated Power at 63° (dBm)	34.5
Path Loss at 63°	145.8
Polarization Loss (dB)	0.2
Ground Antenna Gain (dB)	10.0
Received Level (dBm)	-101.5
IF Bandwidth (dB-Hz)	47.8
Noise Density (dBm / Hz) *	-163.2
CNR Required (dB)	12.0
CNR Margin (dB)	1.9

* Ts = 3467.4 ºK

Table 3.4.4 Standard HRPT Station Predicted Performance (STX-1 Downlink)

Radiated Power at 63° (dBm)	39.2
Path Loss at 63° (dB)	167.7
Polarization Loss (dB)	0.2
Modulation Loss (dB)	0.7
Ground Antenna Gain (dB)	31.0
Demodulator Loss (dB)	3.0
Received Level (dBm)	-101.4
Bit-Rate Bandwidth (dB-Hz) for 665 kbps	58.2
Noise Density (dBm / Hz) *	-174.1
Eb / No Required (dB) for 10^{-6} BER	10.5
Eb / No Margin (dB)	4.0

* Ts = 281.8 ºK

Table 3.4.5 Predicted Platform / DCS / ADCS Performance (Uplink)

DCS Platform Output Power (dBm)	32.0
Cable Loss (dB)	0.5
Platform Feed Loss (dB)	1.0
Platform Antenna Gain (dB)	2.5
Path Loss (dB)	155.2
S/C Antenna Gain (dB)	0.0(@ 63º)
Insertion/VSWR Loss (dB)	1.7
Required Receiver Power Min (dBm)	-128.0
Margin (dB)	4.1

3.4.6 Predicted SARP Link Performance (Uplink)

Table 3.4.6 shows the predicted performance of the Standard SARP Platform reception. The predicted performance was calculated using maximum path loss (63° spacecraft antenna angle).

Table 3.4.6 Predicted Platform / SARP Performance (Uplink)

SARP Platform Output Power (dBm)	37.0
Multipath Loss (dB)	1.0
Platform Antenna Gain (dB)	2.5
Path Loss (dB)	155.2
S/C Antenna Gain (dBil)	-4.5 (@ 63°)
Insertion/VSWR Loss (dB)	2.2
Required Receiver Power Min (dBm)	-131.0
Margin (dB)	7.6

3.4.7 Predicted SARR Link Performance

Table 3.4.7-1 shows the predicted performance of the three SARR uplinks (121.5 MHz, 243.0 MHz and 406.05 MHz) calculated for a 0°-elevation angle. **Table 3.4.7-2** shows the predicted performance of the SARR's L-Band (1544.5 MHz) downlink calculated for a 5° elevation and a single nominal uplink signal.

Table 3.4.7-1 Predicted SARR Uplink Parameters

	121 MHz Beacon	243 MHz Beacon	406 MHz Beacon
ELT / EPIRB Radiated Power (dBm)	15.74	15.74	37.0
Multipath Loss (dB)	4.0	1.0	1.0
Noise Density (dBm / Hz)	-158.6	-163.8	-168.6
Path Loss at 0° Elevation (dB)	144.8	150.8	155.2
Spacecraft Ant. Gain at 63° (dBci) [see note]	-9.0	-6.0	-10.0
Spacecraft Losses (dB)	2.0	1.9	1.5
Received Signal Level (dBm)	-144.1	-144.0	-130.7
Received Signal-to-Noise Ratio (dB Hz)	14.5	17.9	39.4

Note: RHCP antenna as measured with a linearly polarized source.

Table 3.4.7-2 Predicted SARR Downlink Power Budget (For a Single Nominal Uplink Signal)

	121 MHz Relay	243 MHz Relay	406 MHz Relay	PDS Data
Required Signal-to-Noise Min. (dB-Hz)	50.0	46.0	52.2	47.0
Path Loss at 5° Elevation (dB)	165.4	165.4	165.4	165.4
LUT G / T (dB / °K)	3.0	3.0	3.0	3.0
Boltzmann's Constant (dBm / °K / Hz)	-198.6	-198.6	-198.6	-198.6
Spacecraft Antenna Gain (dB)	-1.0	-1.0	-1.0	-1.0
Required Transmitter Power (dBm)	14.8	10.8	17.0	11.8
Transmitter Power Min (dBm)	38.6	38.6	38.6	38.6
Spacecraft Losses (dB)	1.6	1.6	1.6	1.6
Link Margin (dB)	22.2	26.2	20.0	25.2

3.4.8 Predicted CDA Link Performance (Downlink)

Tables 3.4.8-1 to **Table 3.4.8-8** present the predicted VHF, L-Band and S-Band received power at the CDA stations for LAC, GAC, HRPT, stored TIP and Boost Mode telemetry Playback transmissions as calculated at a 63° spacecraft antenna angle. Additionally, **Figures 3.4.8-1** to **Figure 3.4.8-10** present the predicted CDA reception, of the various data streams, as a function of antenna angle.

Table 3.4.8-1 Beacon CDA Sensitivity 137.35 MHz – 137.77 MHz (Wallops)

Parameter	26 Meter Antenna	14.2 Meter Antenna
Polarization Loss (dB)	0.2	0.2
Modulation Loss (dB)	0.7	0.7
Ground Antenna Gain (dB)	27.4	22.41
Bit-Rate Bandwidth (dB-Hz) for 8.3 Kbps	39.2	39.2
Noise Density (dBm / Hz)	-169.5	-169.5
Demodulator Loss (dB)	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5
CDA Sensitivity (dBm)	-143.7	-138.7

Table 3.4.8-2 Beacon CDA Sensitivity 137.35 MHz – 137.77 MHz (Fairbanks)

Parameter	26 Meter Antenna	12 Meter Antenna
Polarization Loss (dB)	0.2	0.2
Modulation Loss (dB)	0.7	0.7
Ground Antenna Gain (dB)	27.4	16.0
Bit-Rate Bandwidth (dB-Hz)	39.2	39.2
Noise Density (dBm / Hz)	-169.5	-169.5
Demodulator Loss (dB)	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5
CDA Sensitivity (dBm)	-143.7	-138.7

Table 3.4.8-3 L – Band CDA Sensitivity 1698.0 MHz – 1707.0 MHz (Wallops 26 Meter Antenna)

	Type of Data Transmission			
Parameter	LAC/GAC (2.66 Mbps)	LAC/GAC (1.33 Mbps)	HRPT (0.66 Mbps)	Stored TIP (0.33 Mbps)
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Premodulator Loss (dB)	1.2	0.8	0.4	0.2
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Adjacent Channel Loss (dB)	10.8	10.6	8.5	5.1
Ground Antenna Gain (dB)	43.6	43.6	43.6	43.6
Bit-Rate Bandwidth (dB-Hz)	64.2	61.2	58.2	55.2
Noise Density (dBm / Hz) *	-173.0	-173.0	-173.0	-173.0
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-124.5	-128.1	-133.6	-140.2

* See Table 3.3.9-1, for Ts = 362.7º

Table 3.4.8-4 L – Band CDA Sensitivity 1698.0 MHz – 1707.0 MHz (Wallops 14.2 Meter Antenna)

	Type of Data Transmission			
Parameter	**LAC/GAC (2.66 Mbps)**	**LAC/GAC (1.33 Mbps)**	**HRPT (0.66 Mbps)**	**Stored TIP (0.33 Mbps)**
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Premodulator Loss (dB)	1.2	0.8	0.4	0.2
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Adjacent Channel Loss (dB)	10.8	10.6	8.5	5.1
Ground Antenna Gain (dB)	43.9	43.9	43.9	43.9
Bit-Rate Bandwidth (dB-Hz)	64.2	61.2	58.2	55.2
Noise Density (dBm / Hz) *	-177.1	-177.1	-177.1	-177.1
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-128.7	-132.3	-137.8	-144.4

* For Ts = 142.2º K

Table 3.4.8-5 L – Band CDA Sensitivity 1698.0 MHz – 1707.0 MHz (Fairbanks 26 Meter Antenna)

	Type of Data Transmission			
Parameter	**LAC/GAC (2.66 Mbps)**	**LAC/GAC (1.33 Mbps)**	**HRPT (0.66 Mbps)**	**Stored TIP (0.33 Mbps)**
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Premodulator Loss (dB)	1.2	0.8	0.4	0.2
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Adjacent Channel Loss (dB)	10.8	10.6	8.5	5.1
Ground Antenna Gain (dB)	48.7	48.7	48.7	48.7
Bit-Rate Bandwidth (dB-Hz)	64.2	61.2	58.2	55.2
Noise Density (dBm / Hz) *	-174.2	-174.2	-174.2	-174.2
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-130.6	-134.2	-139.7	-146.3

* For Ts = 275.4º K

Table 3.4.8-6 L – Band CDA Sensitivity 1698.0 MHz - 1707.0 MHz (Fairbanks 12 Meter Antenna)

	Type of Data Transmission			
Parameter	**LAC/GAC (2.66 Mbps)**	**LAC/GAC (1.33 Mbps)**	**HRPT (0.66 Mbps)**	**Stored TIP (0.33 Mbps)**
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Premodulator Loss (dB)	1.2	0.8	0.4	0.2
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Adjacent Channel Loss (dB)	10.8	10.6	8.5	5.1
Ground Antenna Gain (dB)	43.7	43.7	43.7	43.7
Bit-Rate Bandwidth (dB-Hz)	64.2	61.2	58.2	55.2
Noise Density (dBm / Hz) *	-169.5	-169.5	-169.5	-169.5
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-120.9	-124.5	-130.0	-136.6

* For Ts = 813º K

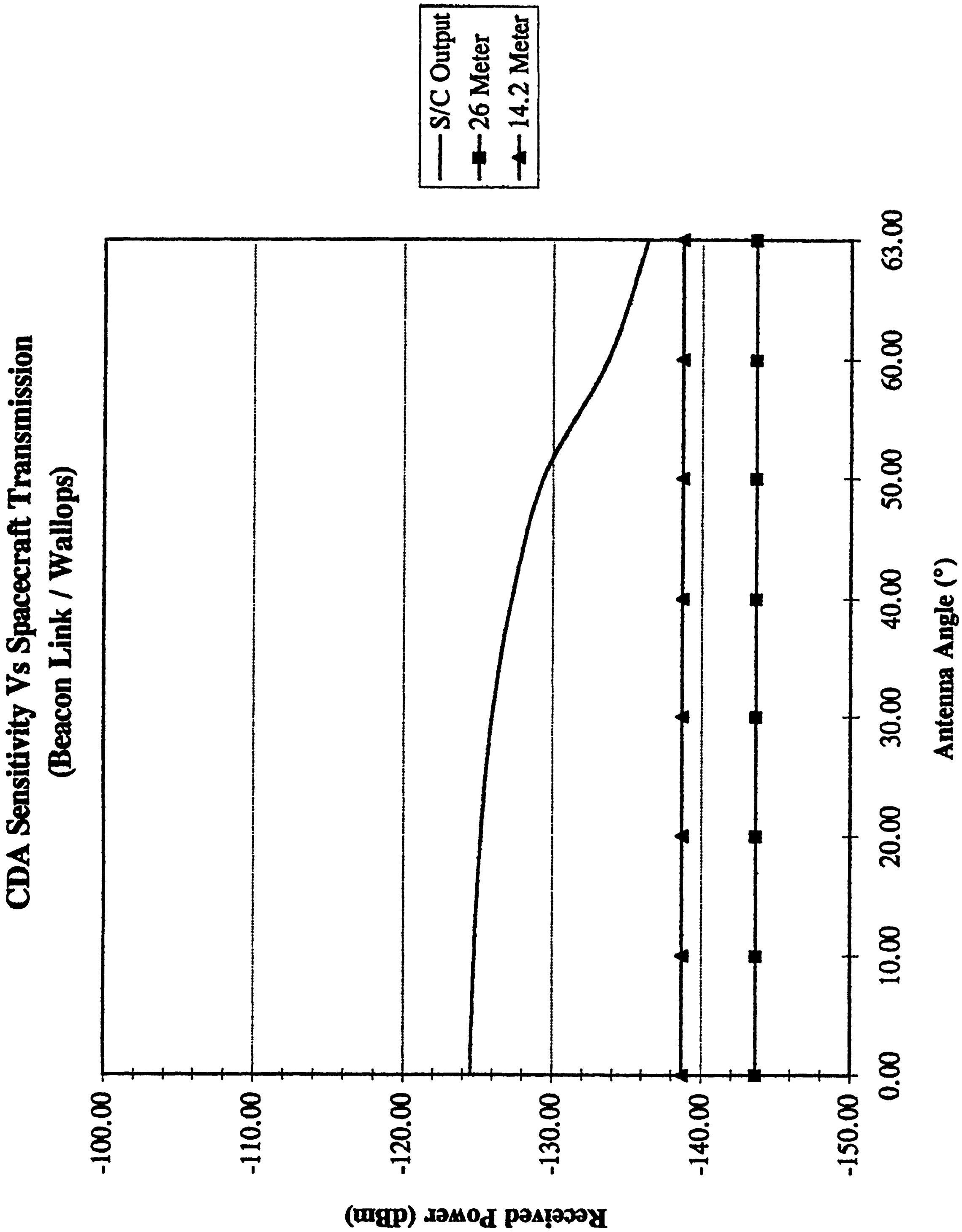
Table 3.4.8-7 L / S – Band CDA Sensitivity 1702.5 MHz / 2247.5 MHz (Wallops CDA)

	26 Meter Antenna		**14.2 Meter Antenna**	
Parameter	**1702.5 MHz**	**2247.5 MHz**	**1702.5 MHz**	**2247.5 MHz**
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Ground Antenna Gain (dB)	43.6	48.7	43.9	46.5
Bit-Rate Bandwidth (dB-Hz) for 8.3 Kbps	39.2	39.2	39.2	39.2
Noise Density (dBm / Hz) *	-173.0	-174.0	-177.1	-176.6
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-161.5	-166.9	-165.6	-167.4

* Refer to Table 3.3.9-1 for Ts

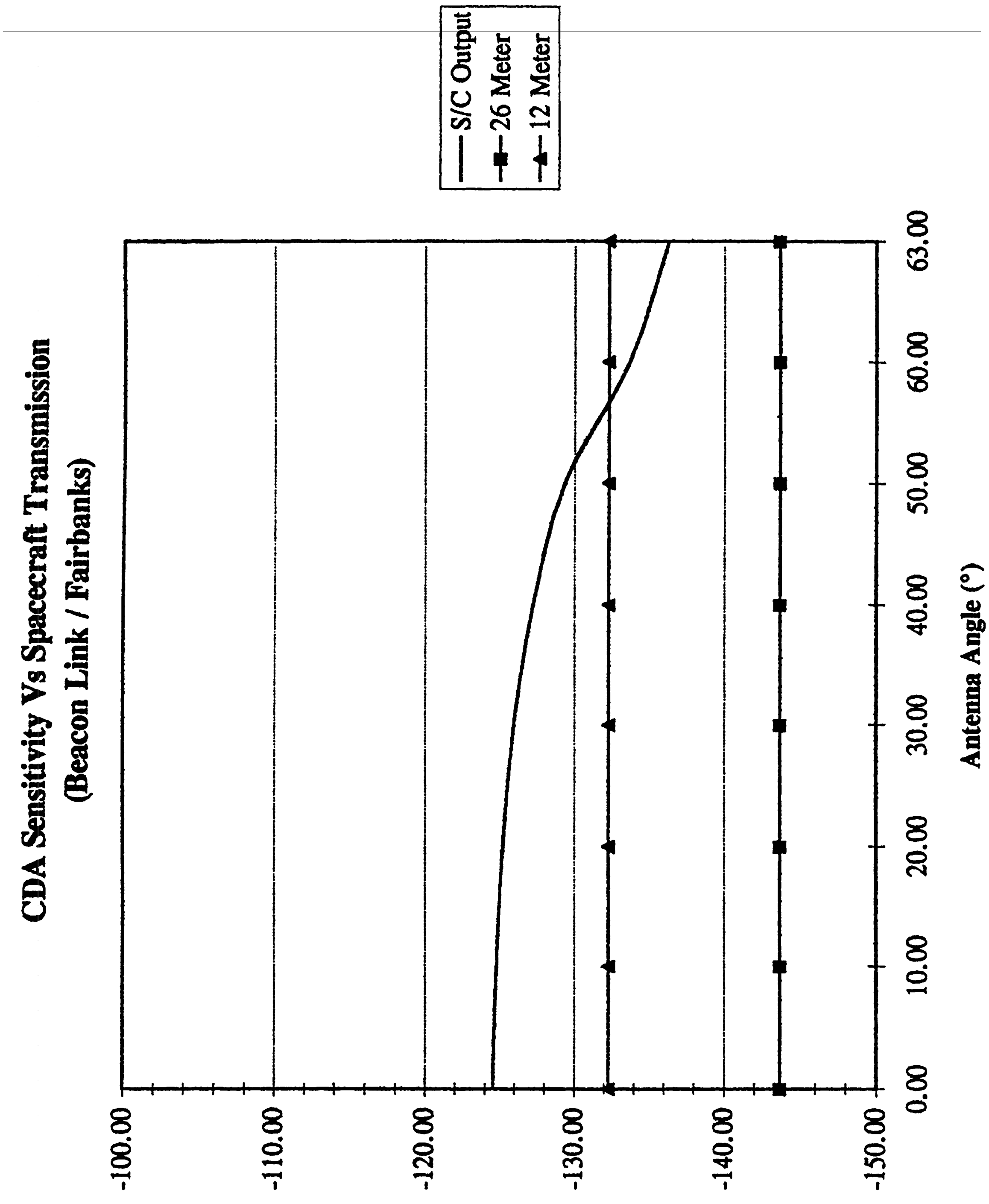
Table 3.4.8-8 L / S – Band CDA Sensitivity 1702.5 MHz / 2247.5 MHz (Fairbanks CDA)

	26 Meter Antenna		12.0 Meter Antenna	
Parameter	**1702.5 MHz**	**2247.5 MHz**	**1702.5 MHz**	**2247.5 MHz**
Polarization Loss (dB)	1.5	1.5	1.5	1.5
Modulation Loss (dB)	0.7	0.7	0.7	0.7
Rain Fade Loss (dB)	0.4	0.4	0.4	0.4
Ground Antenna Gain (dB)	48.7	51.8	43.7	46.0
Bit-Rate Bandwidth (dB-Hz)	39.2	39.2	39.2	39.2
Noise Density (dBm / Hz)	-174.2	-174.5	-169.5	-172.3
Demodulator Loss (dB)	3.0	3.0	3.0	3.0
Eb / No Required (dB), 10^{-6} BER	10.5	10.5	10.5	10.5
CDA Sensitivity (dBm)	-167.6	-171.0	-157.9	-163.9



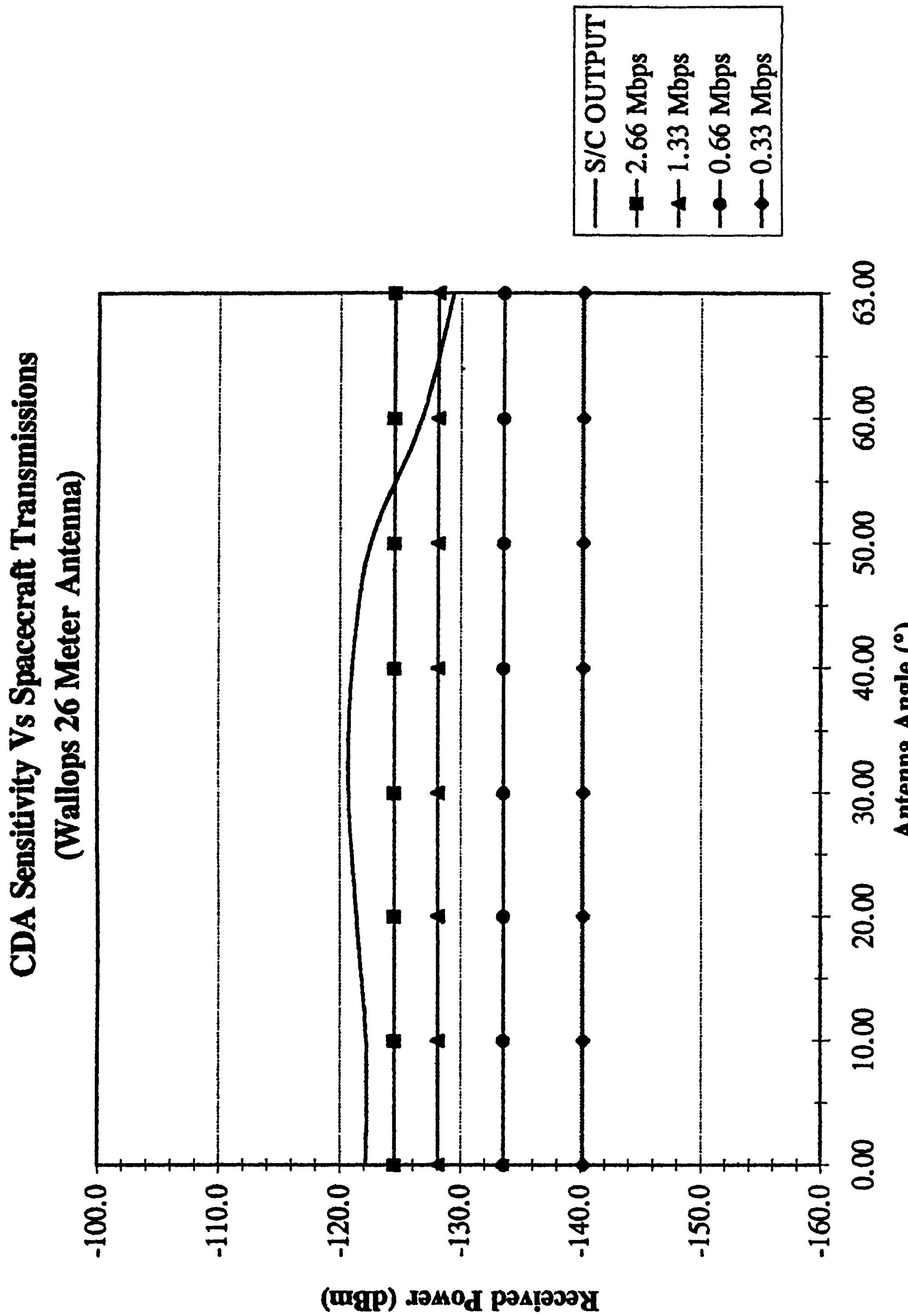
F00022_9

Figure 3.4.8-1 CDA Sensitivity Vs Spacecraft Transmission (Beacon Link / Wallops)



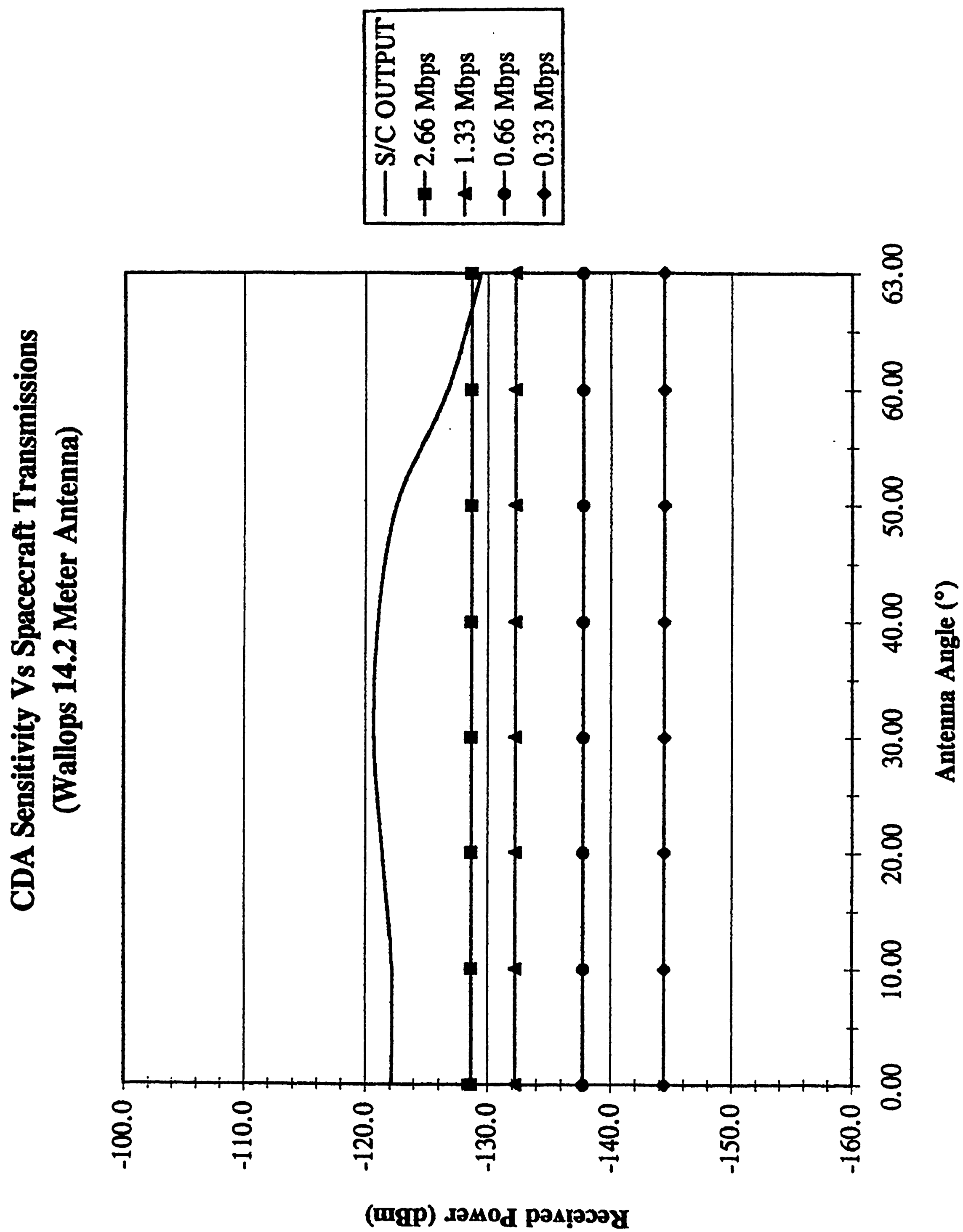
F00022_10

Figure 3.4.8-2 CDA Sensitivity Vs Spacecraft Transmission (Beacon Link / Fairbanks)



F00022_11

Figure 3.4.8-3 L-Band CDA Sensitivity – (L-Band 26 M Wallops)



F00022_12

Figure 3.4.8-4 L-Band CDA Sensitivity – (L-Band 14.2 Wallops)

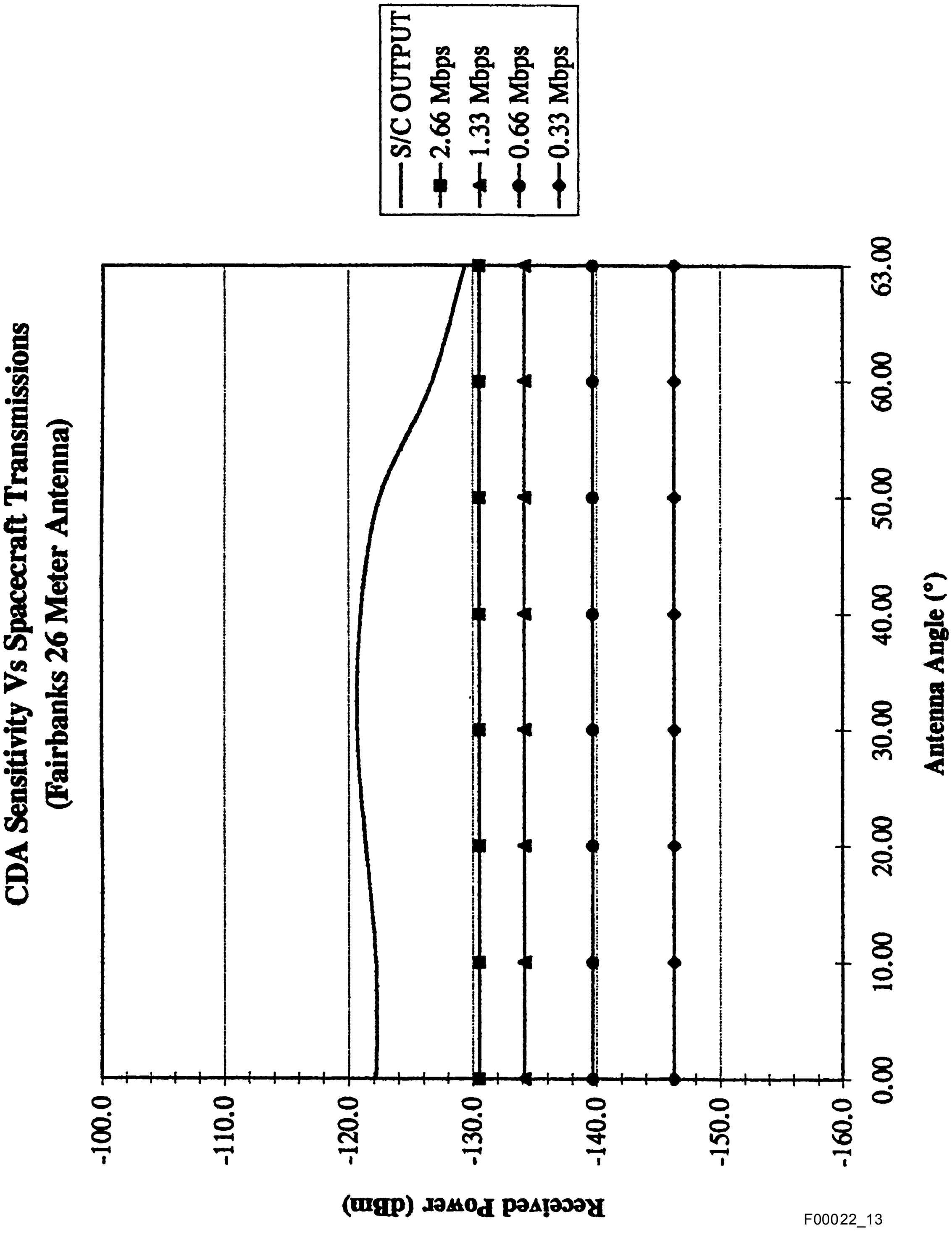


Figure 3.4.8-5 L-Band CDA Sensitivity – (L-Band 26 M Fairbanks)

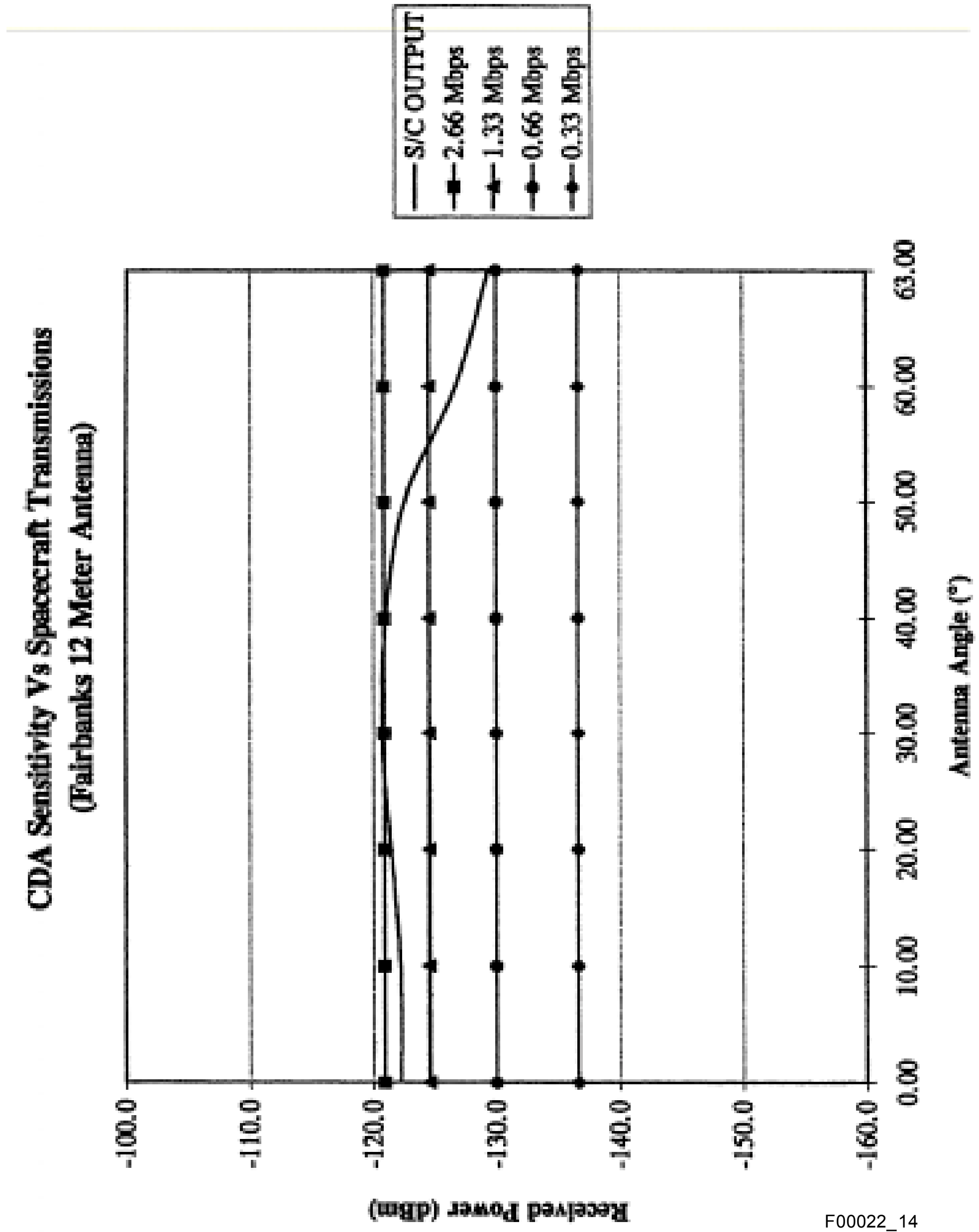
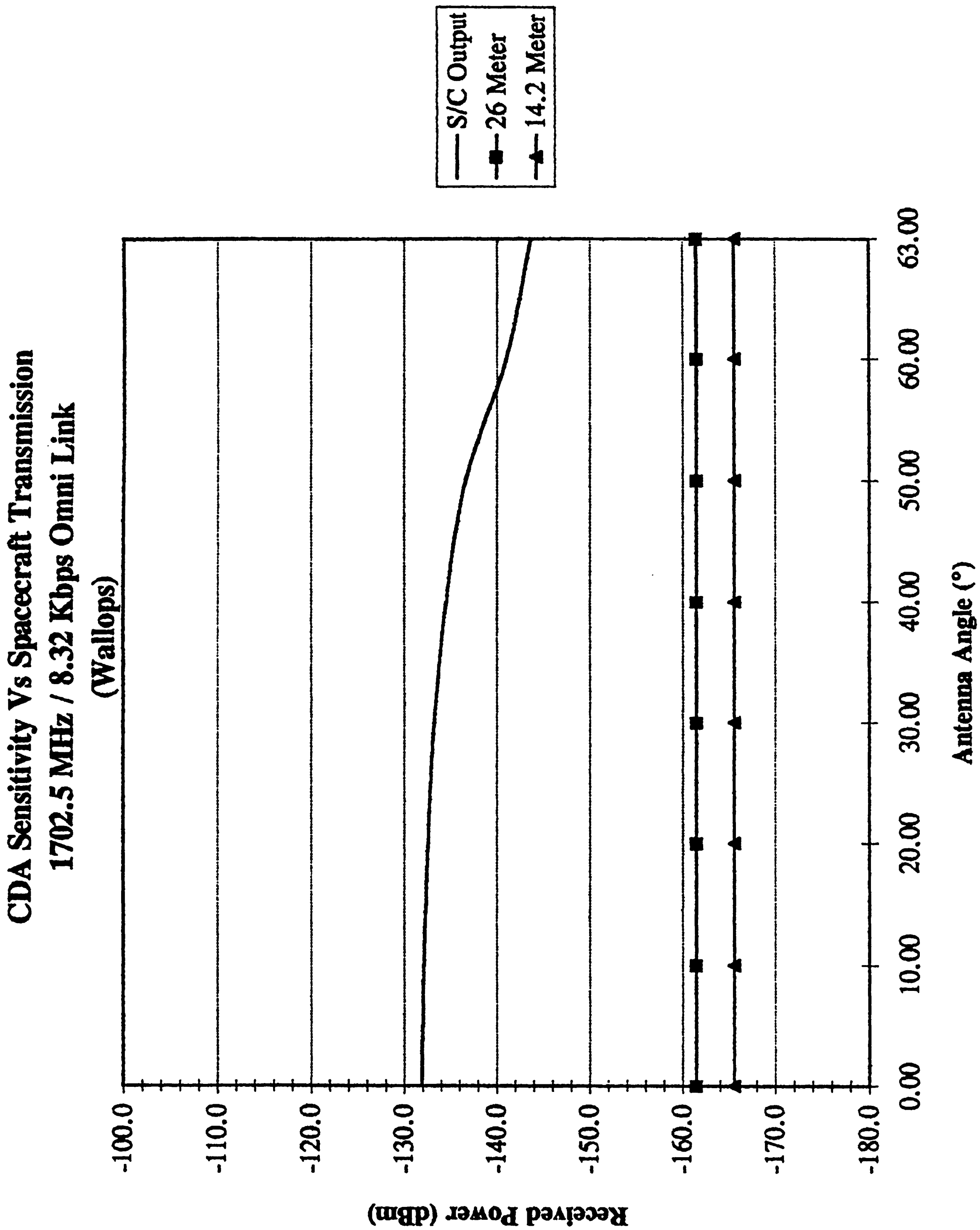
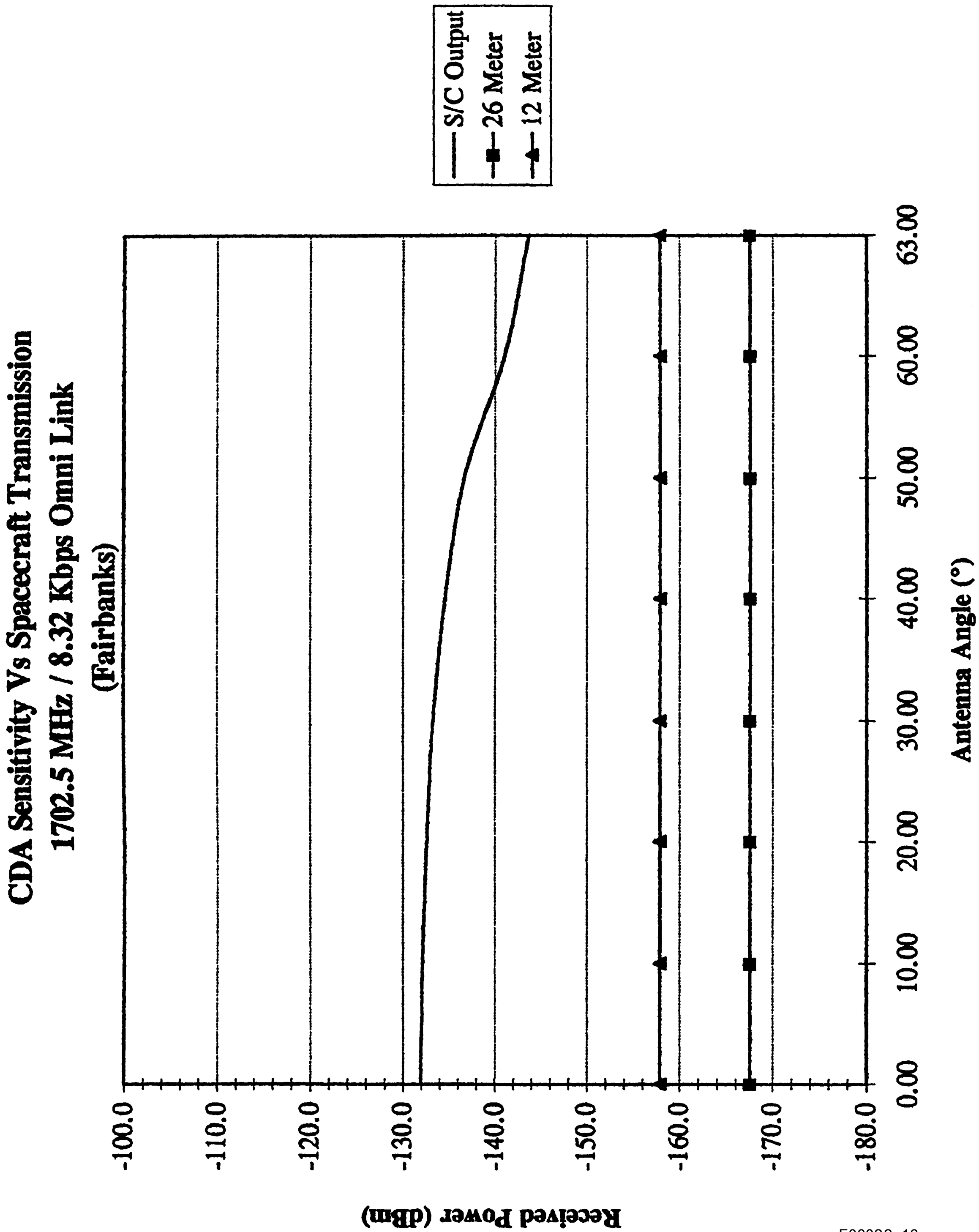


Figure 3.4.8-6 L-Band CDA Sensitivity – (L Band 12 M Fairbanks)



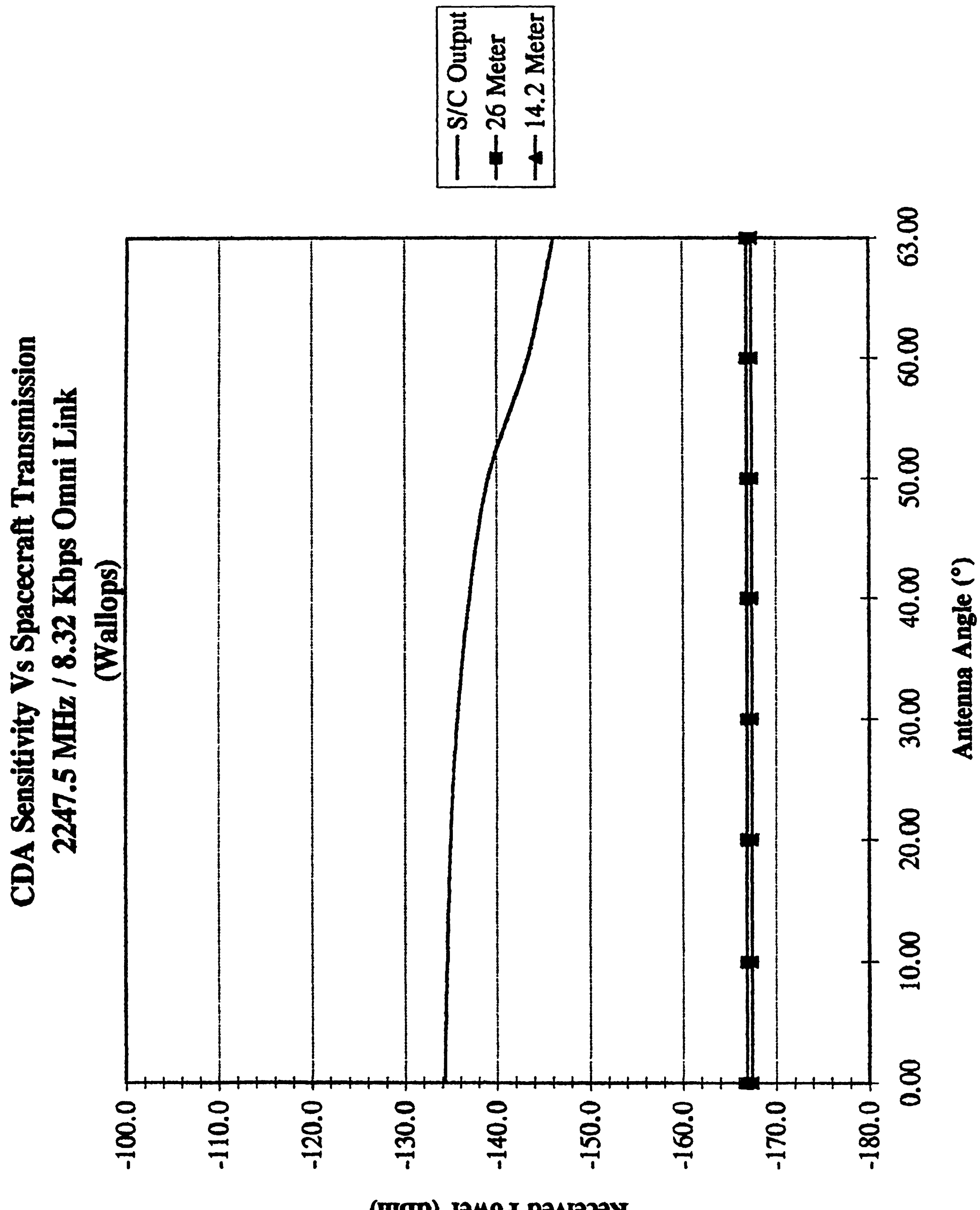
F00022_15

Figure 3.4.8-7 1702.5 MHz / 8.32 Kbps Omni Link – (Wallops)



F00022_16

Figure 3.4.8-8 1702.5 MHz / 8.32 Kbps Omni Link – (Fairbanks)



F00022_17

Figure 3.4.8-9 2247.5 MHz / 8.32 Kbps Omni Link – (Wallops)

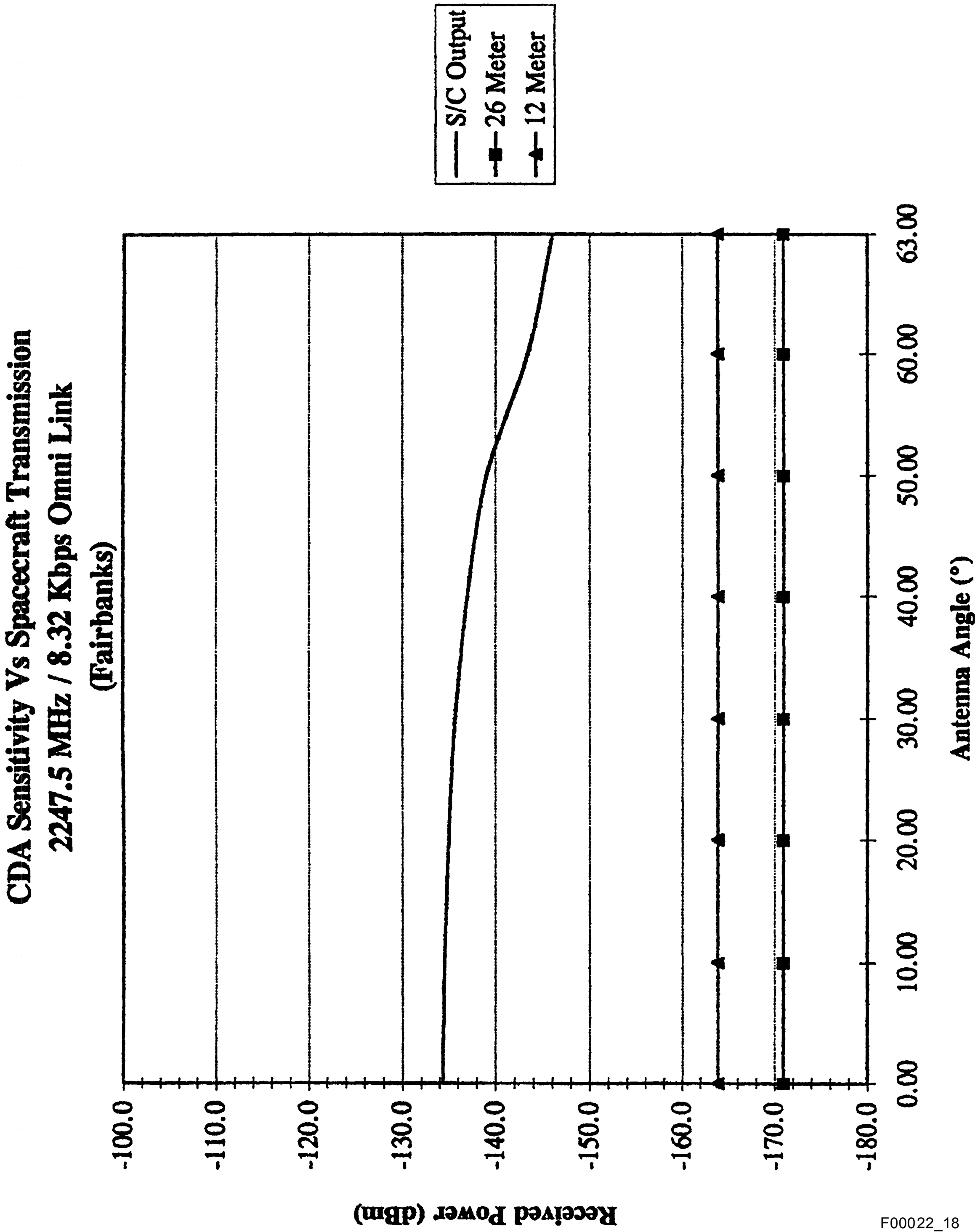


Figure 3.4.8-10 2247.5 MHz / 8.32 Kbps Omni Link – (Fairbanks)

3.4.9 CDA Command Transmission

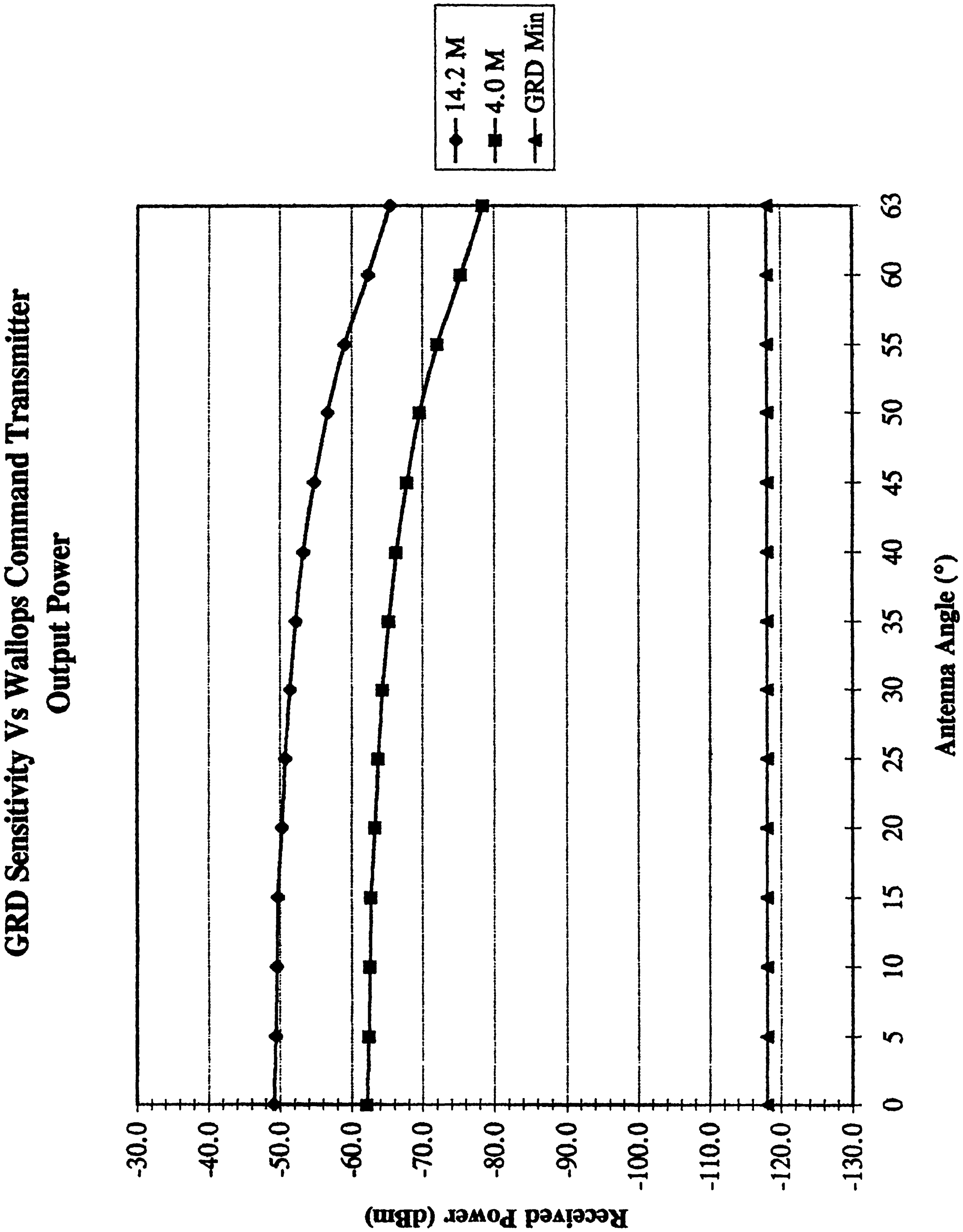
The predicted performance of the CDA Command Transmissions, as seen by the spacecraft, as calculated for a 63º spacecraft antenna angle is shown in **Table 3.4.9-1** and **Table 3.4.9-2.** Additionally, the predicted link performance as a function of antenna angle is shown in **Figure 3.4.9-1** and **Figure 3.4.9-2**.

Table 3.4.9-1 Predicted Wallops CDA Command Transmissions

	Wallops 14.2 Meter Ant.	Wallops 4 Meter Ant.
GRD Sensitivity (dBm)	-118.0	-118.0
Spacecraft Losses (dB)	6.0	6.0
S/C Antenna Gain (dBci)	0.0 (@ 63°)	0.0 (@ 63°)
Polarization Loss (dB)	0.2	0.2
Path Loss (dB, 63°)	169.2	169.2
Min Required GRD Received Power (dBm)	57.4	57.4
CDA Transmitter EIRP (dBm)	110.0	97.0
Link Margin (dB)	52.6	39.6

Table 3.4.9-2 Predicted Fairbanks CDA Command Transmissions

	Fairbanks 6 Meter Ant.	Fairbanks 4 Meter Ant.
GRD Sensitivity (dBm)	-118.0	-118.0
Spacecraft Losses (dB)	6.0	6.0
S/C Antenna Gain (dBci)	0.0 (@ 63°)	0.0 (@ 63°)
Polarization Loss (dB)	0.2	0.2
Path Loss (dB, 63°)	169.2	169.2
Min Required GRD Received Power (dBm)	57.4	57.4
CDA Transmitter EIRP (dBm)	102.0	97.0
Link Margin (dB)	44.6	39.6



F00022_19

Figure 3.4.9-1 Wallops S-Band Command Performance

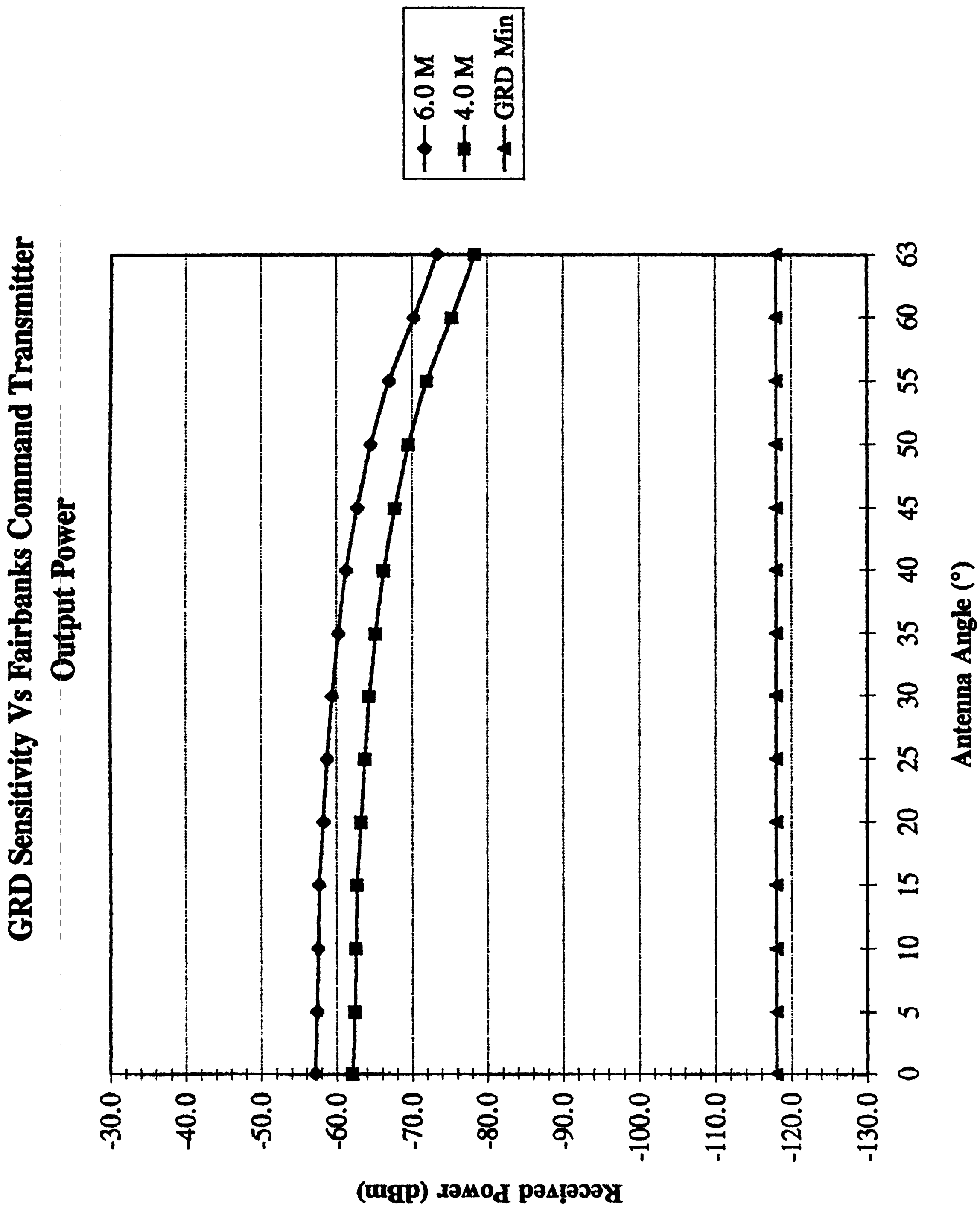


Figure 3.4.9-2 Fairbanks S-Band Command Performance

APPENDIX A
PATH LOSS INFORMATION

Table A-1 Path Loss (dB) Vs Frequency (MHz) Spacecraft Transmitter Frequencies

Antenna Angle (°)	2247.5	1707.0	1544.5	137.77	137.6
0	158.29	155.90	155.04	134.04	134.03
5	158.52	156.13	155.26	134.27	134.26
10	158.55	156.16	155.30	134.30	134.29
15	158.61	156.22	155.35	134.36	134.35
20	158.98	156.59	155.73	134.73	134.72
25	159.26	156.87	156.00	135.01	135.00
30	159.69	157.30	156.43	135.44	135.43
35	160.35	157.96	157.10	136.10	136.09
40	161.01	158.62	157.76	136.76	136.75
45	161.99	159.60	158.74	137.74	137.73
50	163.11	160.72	159.86	138.86	138.85
55	164.74	162.35	161.49	140.49	140.48
60	167.43	165.04	164.17	143.18	143.19
61	168.51	166.12	165.26	144.26	144.25
62	170.10	167.71	166.85	145.85	145.84

Note: Path Loss calculations were performed utilizing the following equation:

$L = 36.6 + 20 \text{ Log (MHz)} + 20 \text{ Log (mi)}$

Table A-2 Path Loss (dB) Vs Frequency (MHz) Spacecraft Receiver Frequencies

Antenna Angle (°)	2026.0	406.05	401.65	243.0	121.5
0	157.39	143.43	143.34	138.97	132.95
5	157.62	143.65	143.57	139.19	133.17
10	157.65	143.69	143.60	139.23	133.21
15	157.71	143.75	143.66	139.29	133.27
20	158.08	144.12	144.03	139.66	133.64
25	158.36	144.40	144.31	139.94	133.92
30	158.79	144.82	144.74	140.36	134.34
35	159.45	145.49	145.40	141.03	135.01
40	160.11	146.15	146.06	141.69	135.67
45	161.09	147.13	147.04	142.67	136.65
50	162.21	148.25	148.16	143.79	137.77
55	163.84	149.88	149.79	145.42	139.40
60	166.53	152.56	152.48	148.10	142.08
61	167.61	153.65	153.56	149.19	143.17
62	169.20	155.24	155.15	150.78	144.76

Note: Path Loss calculations were performed utilizing the following equation:

L = 36.6 + 20 Log (MHz) + 20 Log (mi)

Table A-3 Spacecraft Distance Vs Antenna Angle / Ground Elevation

Antenna Angle (°)	Elevation (°)	Distance (mi)
0	90.0	540.8
5	84.3	555.0
10	78.6	557.0
15	72.9	561.0
20	67.1	585.6
25	61.3	604.5
30	55.4	635.0
35	49.3	685.5
40	43.1	740.0
45	36.5	827.6
50	29.5	941.8
55	21.4	1136.5
60	10.2	1548.5
61	6.2	1754.1
62	0.0	2105.0

Note: The following parameters were utilized in the calculation of Spacecraft Elevation and Spacecraft Distance:

Earth Radius = 3959.0 mi.

Spacecraft Orbit = 540.8 mi.

APPENDIX B
SPACECRAFT ANTENNA GAIN INFORMATION

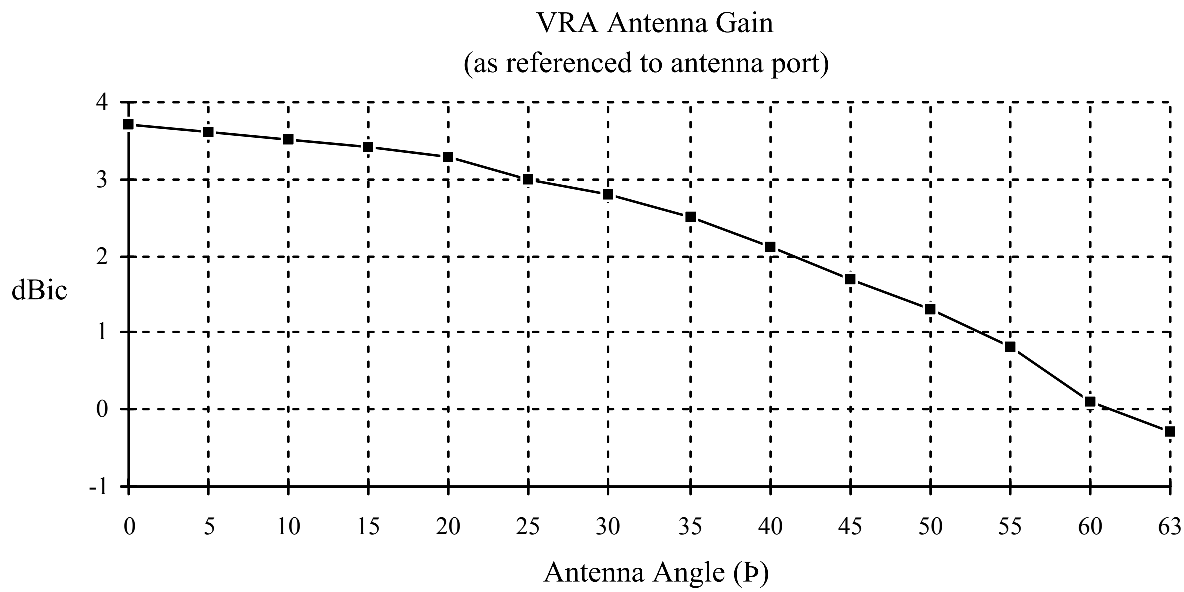


Figure B–1

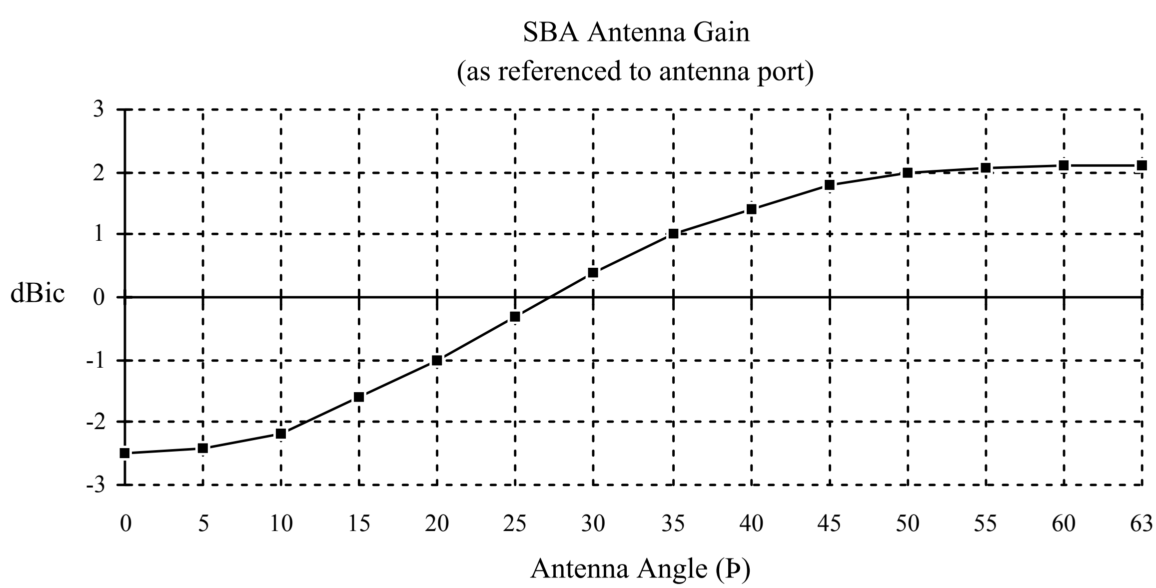


Figure B–2

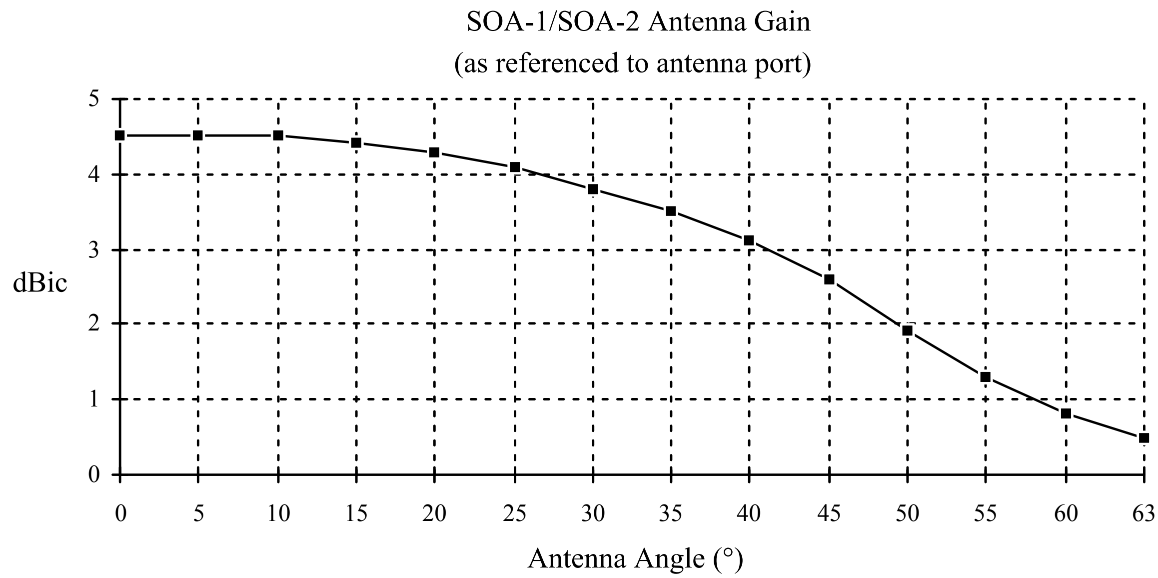


Figure B–3

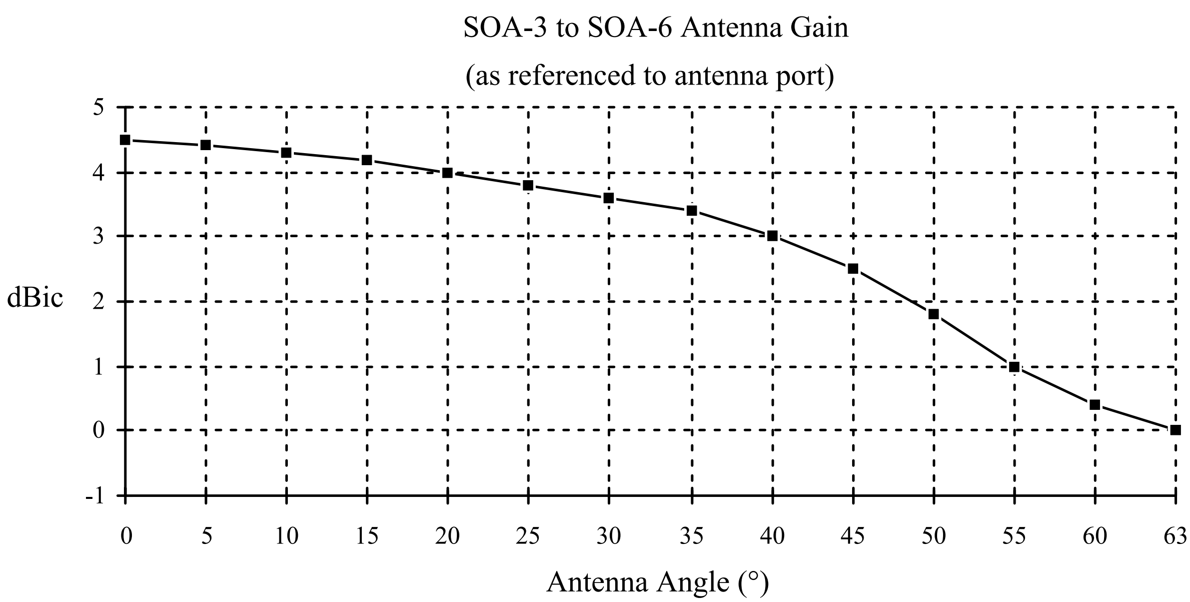


Figure B–4

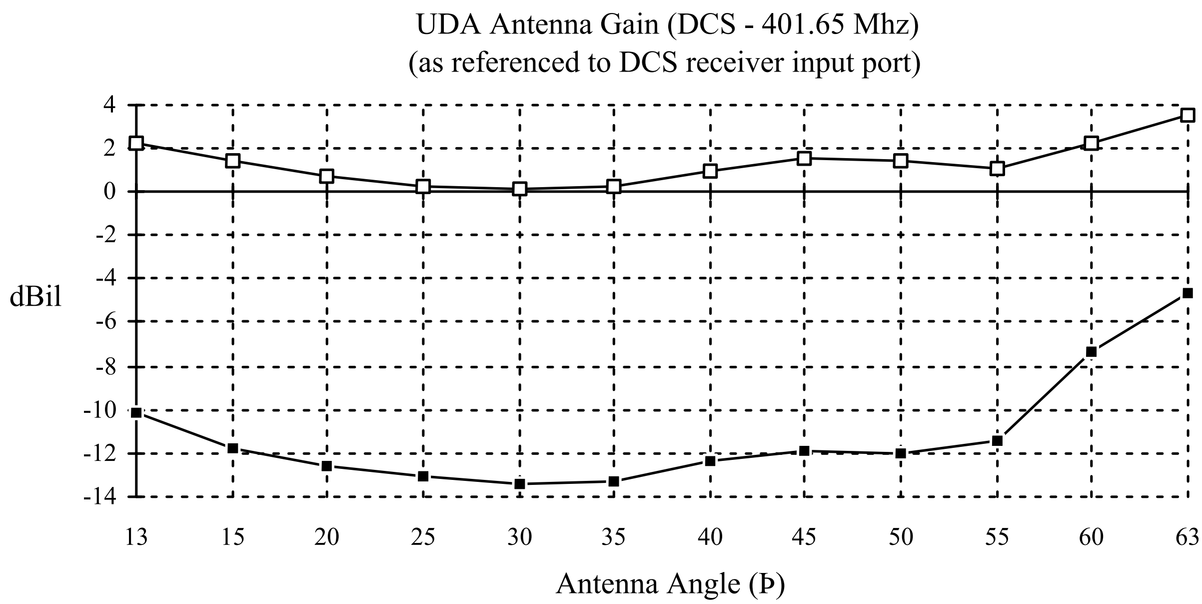


Figure B–5

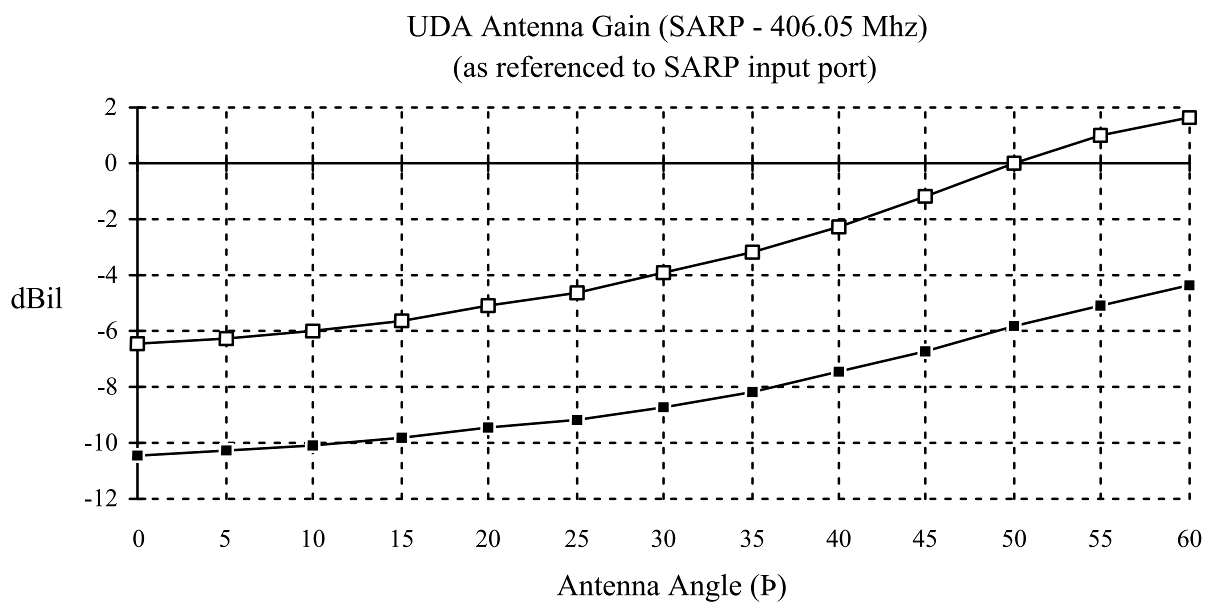


Figure B–6

SRA 121.5 Mhz Antenna Gain
(as referenced to SARR input port)

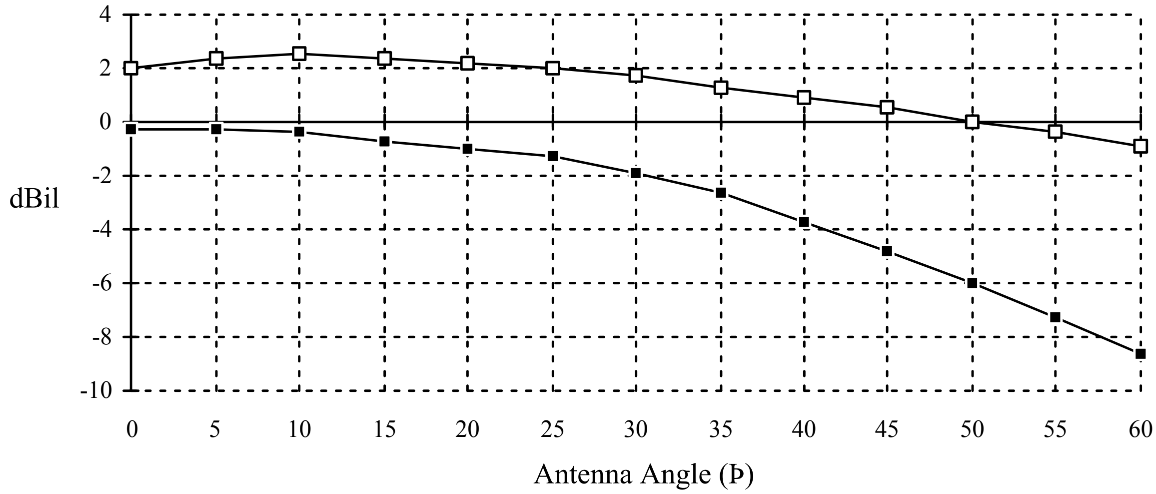


Figure B–7

SRA 243 Mhz Antenna Gain
(as referenced to SARR input port)

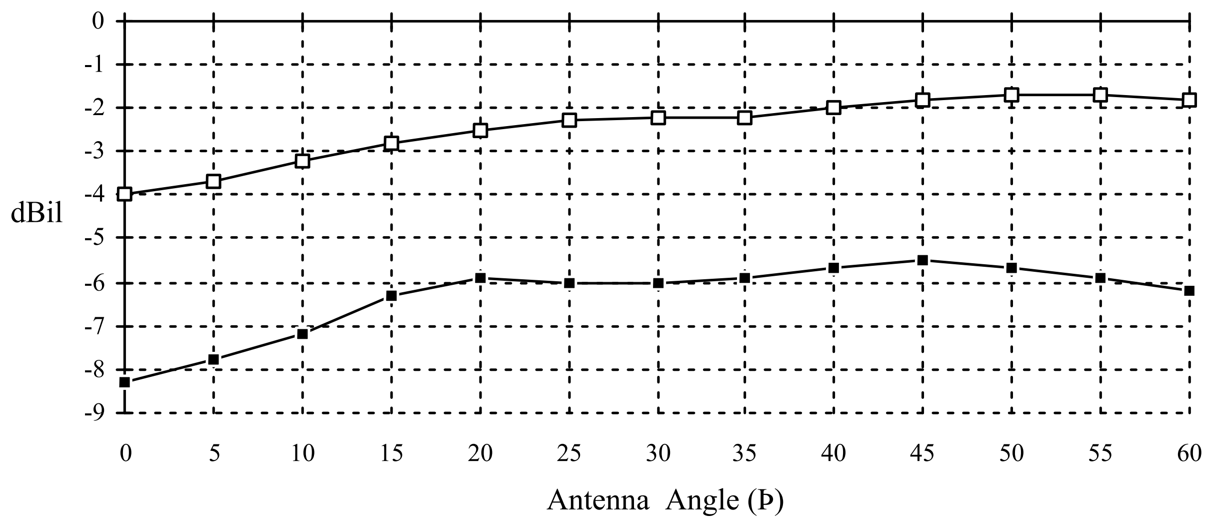


Figure B–8

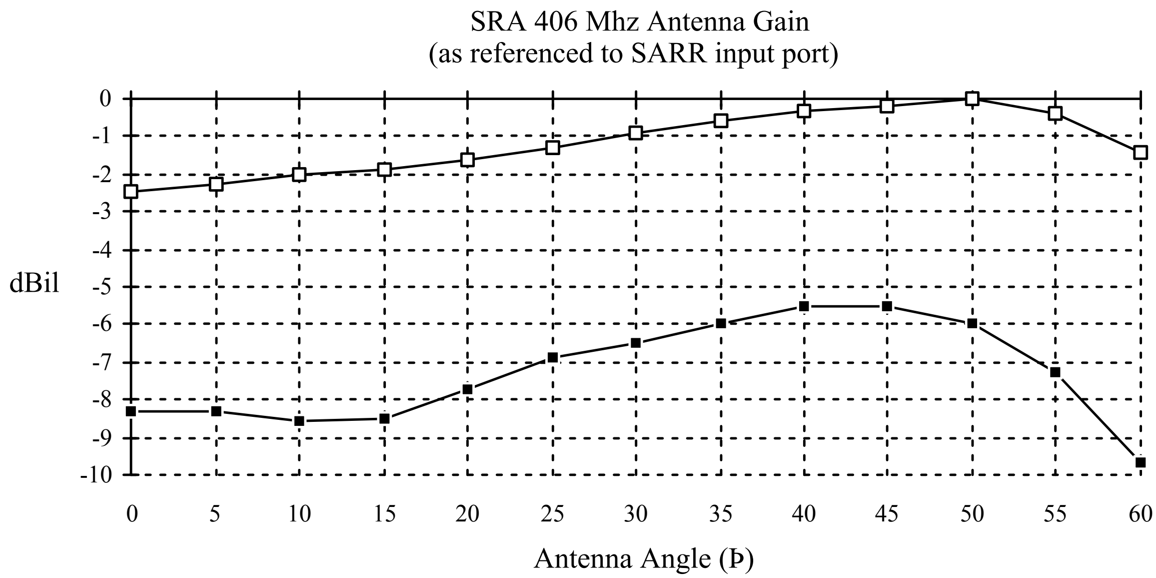


Figure B–9

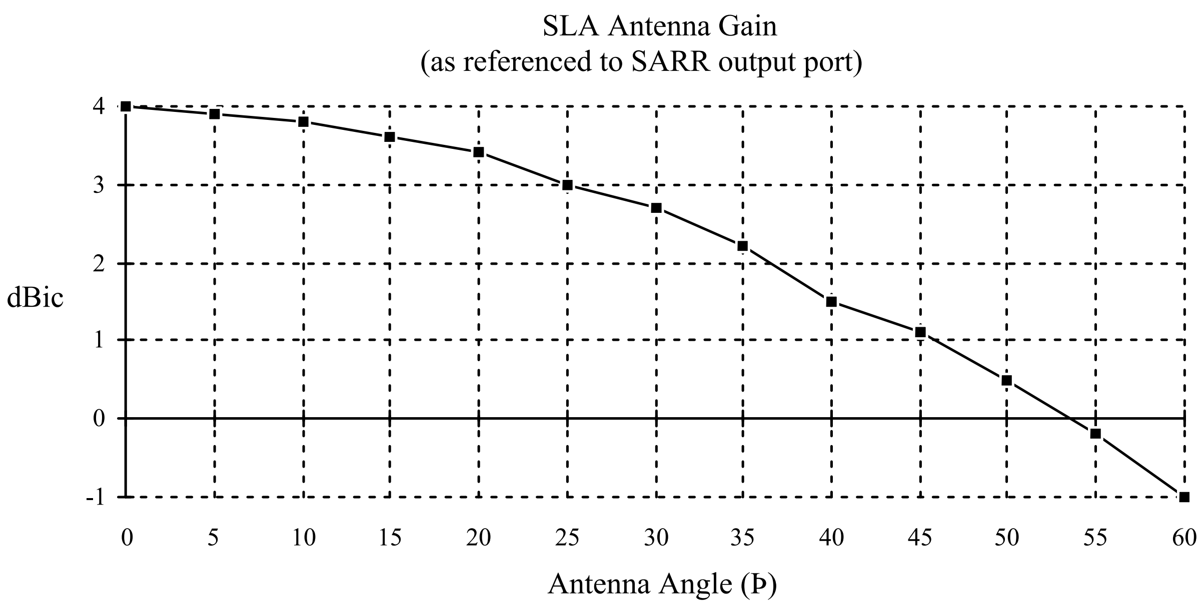


Figure B–10

ADA Antenna Gain
(as referenced to the ADCS output port)

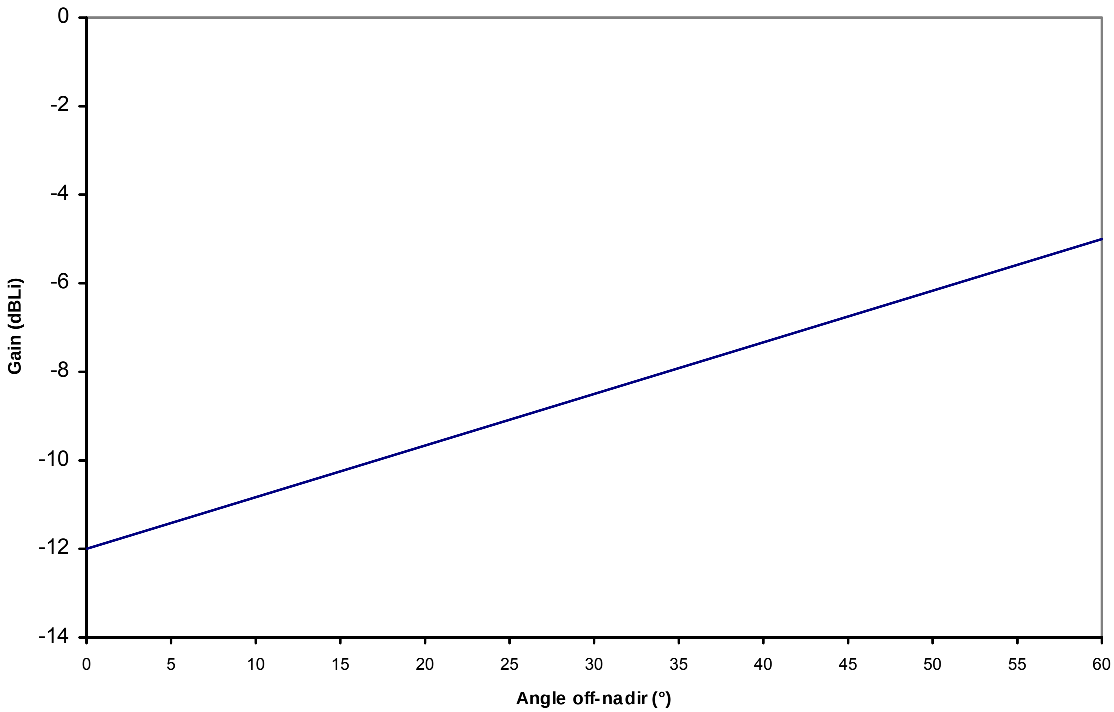

0
-2
-4
-6
-8
-10
-12
-14
Gain (dBLi)
0
5
10
15
20
25
30
35
40
45
50
55
60
Angle off-nadir (°)

Figure B–11